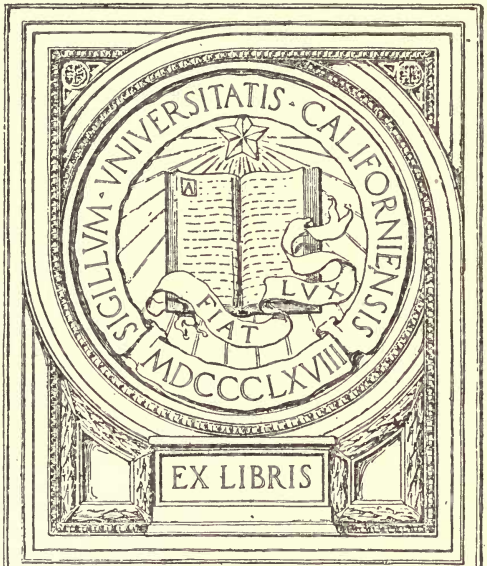
UC-NRLF
B 4 500 090

GIFT OF
Mrs. H. T. Bradley



IFIC PRESS
OK BINDERY

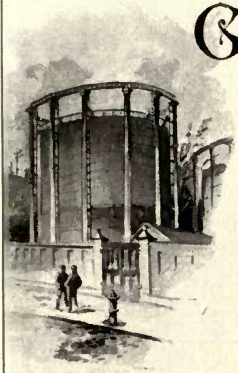
TJ785
.S65

C. E. P.

MODERN GAS AND OIL ENGINES.

By Albert Spies.

First Paper.



GAS engines, at the present day, are common enough, the past ten or twelve years having witnessed the production of a host of designs, although of these probably by far the larger number have gained little more publicity than that afforded by the patent office records of different countries. But the more fortunate ones,—those that have been put into marketable shape and sold for a variety of motive power purposes,—have been sufficient to amply advertise this type of motor and to practically demonstrate its applicability to many, if not all, the uses to which the steam engine has hitherto been put. It would, therefore, seem almost unnecessary to more specifically define it as an engine in which the working fluid is an inflammable gas, or, more correctly, a mixture of atmospheric air and inflammable gas, introduced directly into the engine cylinder and there ignited and burned. All gas engines, while they may differ widely in theory of action and mechanical construction, possess in common this one feature of heating the working fluid in their cylinders proper. Compared with the steam engine as a familiar example, and with most hot air engines, we thus find in the gas engine relative simplicity in so far as no separate furnace is necessary in which to burn the fuel from which the energy is primarily derived; furthermore, the energy is available at exactly the moment needed, and there is no storing up of heat in the same sense as in the steam engine and boiler combination. Hence, it will be seen that the gas engine also has a special applicability in all cases where continuous work is not required.

Concerning the origin of the gas engine there is no definite information. By some it has been dated as far back as the latter part of the seventeenth century when gunpowder was proposed and used for obtaining motive power in special apparatus. These early engines, however, can scarcely be properly classed as gas engines. The first gas engine, in the now accepted sense of the term, was probably that patented in the year 1791, in England, by one John Barber. It provided for the use of coal, wood, oil or any combustible in a retort, the generation of vapor or gas from such combustible, and the collection and cooling of the gas in a reservoir. Thence the gas was taken to a compressor which supplied the motor cylinder, and in this latter the gas was mixed with atmospheric air in proper proportion, and exploded by a light. This engine embodied, in the main, the principle of the modern gas engine. Three years later, in 1794, Thomas Mead and Robert Street both obtained patents in England for gas or vapor engines, Mead proposing to raise the piston in his engine cylinder by the ignition of a gaseous, explosive mixture and to utilize for the down-stroke both the weight of the piston and the partial vacuum formed underneath it. This was, in part, the principle of the much later Otto and Langen engine. Street's engine, on the other hand, partly anticipated the also much later hydrocarbon engine of George Brayton, providing, as it did, for the production of motive power by introducing a few drops of spirits of turpentine into the heated bottom of a cylinder. The tur-

464520

pentine was vaporized by the heat, air was mixed with it in sufficient quantity to produce an explosive compound, and a flame was applied to ignite it. The next patents for gas engines were not issued until nearly thirty years later (1823). From that time on they appeared at shorter intervals until more recently, when design crowded design in rapid succession, so that now the gas engine patents are numbered by the hundreds. The essential differences between the inventions, however, are not very great. In many cases, in fact, it seems sadly true that the inventors have been satisfied with producing simply some detail by which the original patents could be avoided, rather than anything which really marked a step in advance.

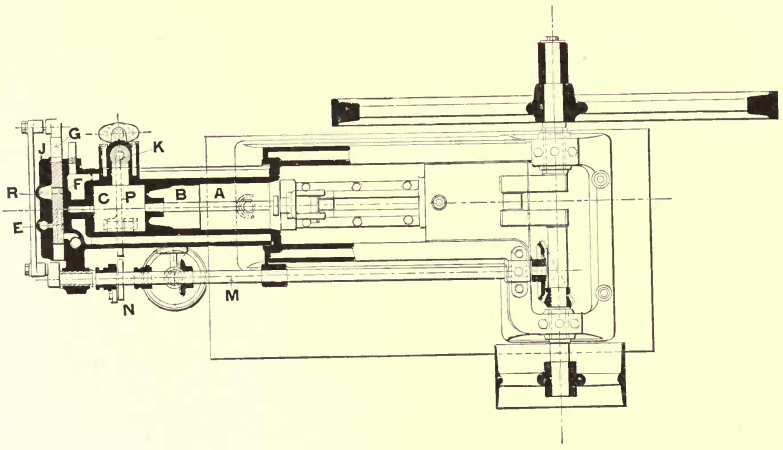


FIG. 1.—PLAN VIEW OF THE ORIGINAL OTTO SLIDE-VALVE ENGINE.

It would be impracticable to here follow the history of the gas engine in anything like detail from its earliest days to the time when it became justly looked upon as a distinctly practical and useful source of power. A few of the types, however, which, though comparatively crude and more or less imperfect, still came into somewhat extended use and practically opened up the era of commercially successful gas engines, deserve mention. The first of these was the Lenoir engine, made even at this date in a modified form, a machine of simple construction, and very similar in appearance to an ordinary horizontal steam engine. The piston moving, say, from the right to the left drew in a mixture of illuminating gas, or of hydrogen, and air through a slide valve worked by the engine. When a certain quantity of this mixture had entered the cylinder, the slide valve shut off the supply and an electric spark from an induction coil kindled the gas and caused an explosion which drove the piston to the other end of its stroke. Arrived there, at the left end, a second slide allowed the products of combustion to escape while the fly wheel, by reason of its momentum, went on and moved the piston in the opposite direction, from left to right. While it moved in this direction, the explosive mixture again entered and was ignited as before, and the piston completed its travel to the right under the impulse of this second explosion. The action, it will be seen, was thus very similar to that of the ordinary, familiar steam engine. To prevent overheating of the cylinder and piston, the former was surrounded with a jacket filled with cold water.

Following the Lenoir engine came that of Hugon, in which the tendency to become overheated was counteracted by introducing into the cylinder, together with the gas and air mixture, a

quantity of water which, in vaporizing, absorbed considerable heat and thus kept the temperature within a reasonable limit. The expansive force of the gases was in this way, it is true, somewhat diminished, but the moving parts suffered less, and the engine required less repair and was more durable. Ignition of the explosive charge was effected by a gas jet.

A number of years after the bringing out of both these engines, Otto and Langen together entered the gas engine field with what they termed their atmospheric or free piston engine for which they were awarded a gold medal at the Paris Exposition in 1867. The main features of this engine are briefly referred to further on.

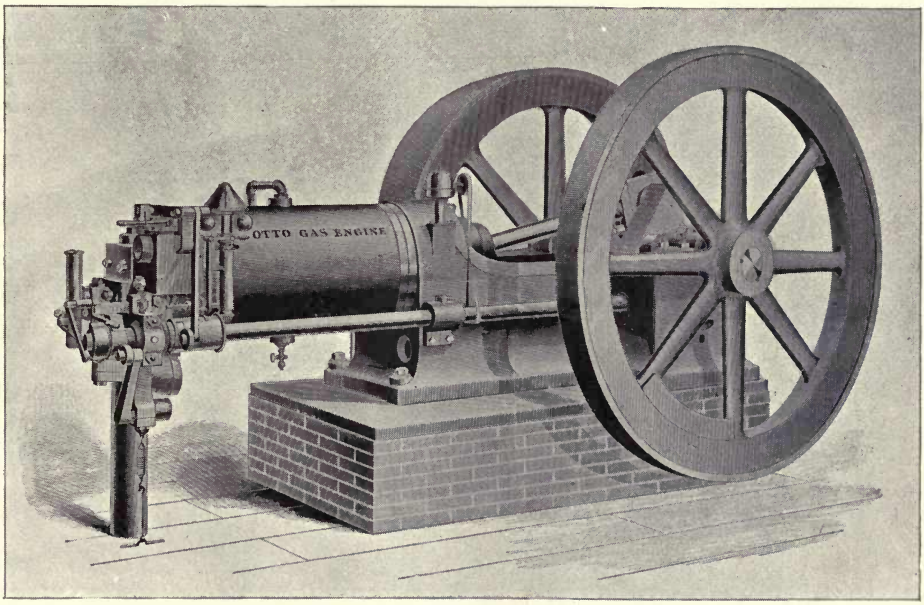


FIG. 2.—THE OTTO GAS ENGINE, BUILT BY SCHLEICHER, SCHUM & CO., PHILADELPHIA, PA.

The Brayton engine, an American invention, was first brought out in 1873. It had two cylinders, one being a compressor and the other a motor cylinder. The charge of gas and air was first drawn into the compressor cylinder on the out-stroke, and on the back-stroke was compressed into a receiver. The motor cylinder took its supply from the receiver, but the mixture was ignited as it entered, a grating arrangement preventing the flame from passing back. The mixture proper, in fact, did not enter the motor cylinder at all; what entered it was a continuous flame and the action, therefore, was not explosive in character. At a certain point the supply was cut off, and the piston moved on to the end of its stroke under the influence of the expansion of the hot gases. The flame grating in this engine, however, was a weak point. If by any accident the grating or wire gauze was pierced, in cleaning for example, the flame went back into the receiver and exploded the whole stored-up mixture. Such accidents became so troublesome that Mr. Brayton after a time discontinued the use of gas and converted his engine into a petroleum motor. Light petroleum was pumped upon the grating and the compressing cylinder charged the receiver with air alone. The air, in subsequently passing through the grating, carried the petroleum along

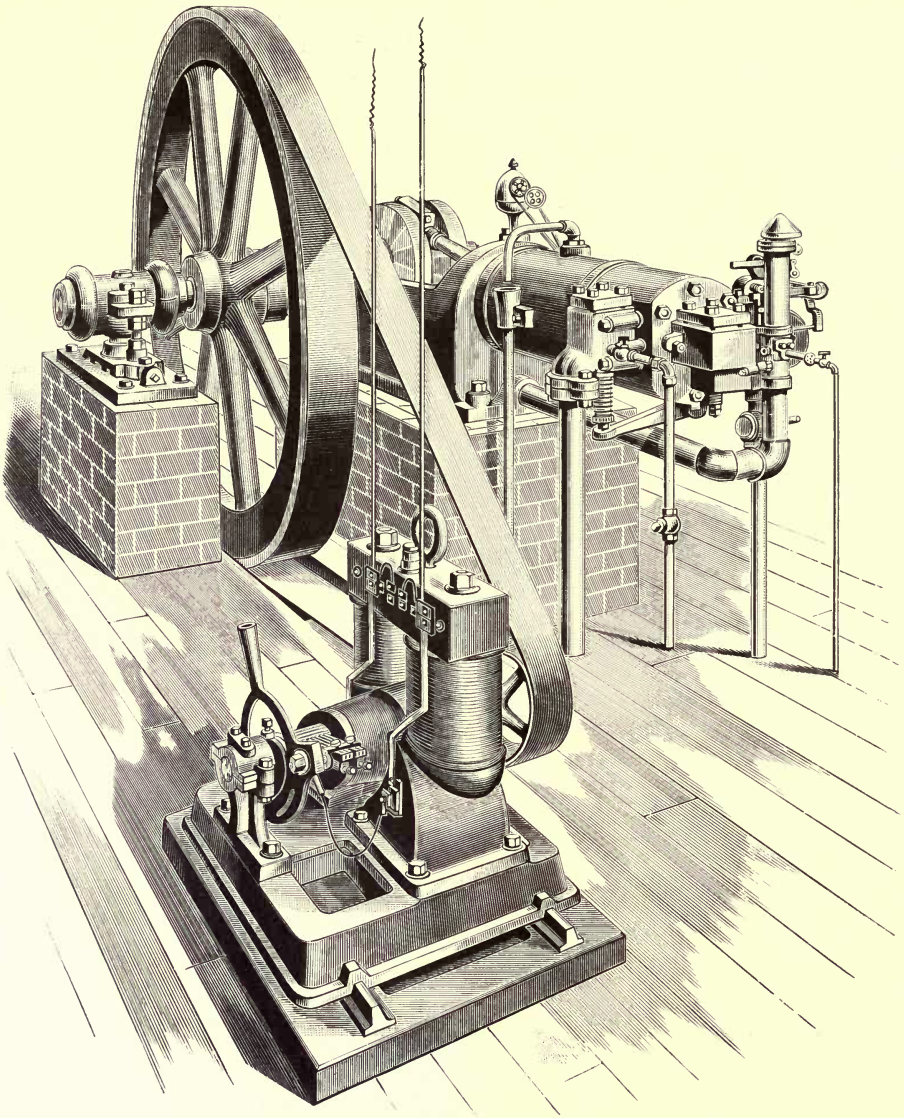


FIG. 3.—OTTO GAS ENGINE AND DYNAMO FOR HOUSE LIGHTING.

with it, partly in vapor, and partly in spray form. This oil vapor and air mixture was then ignited just like the previously used gas mixture. The arrangements, in fact, were precisely similar to those of the gas engine, except in the addition of a small oil pump and a slight alteration in the valve disposition. The engine, as may be understood, was single-acting.

Right here it should be pointed out that the similarity between the original Brayton gas engine and the converted Brayton engine using petroleum is typical, also, of all gas and oil engines of the present day. All the oil engines follow the lines of the gas engines very closely ; in fact, in some of the gas engines now on the market gas or oil mixtures can be used indiscrimi-

nately, the engines working well with either, and without modifications of designs to suit the particular kind of fluid used. A distinct classification into oil motors and gas motors cannot, therefore, be well made, and both may be, very appropriately, considered together under practically one head.

Broadly speaking, however, the various engines, early and modern, and using either gas or oil mixtures, may be divided into a few, well-defined types :

1. Engines drawing into the working cylinder gas or oil vapor and air at atmospheric pressure for a portion of the piston stroke, cutting off communication with the outer air, and igniting the mixture. The pressure of the ignited gases pushes the piston forward during the remainder of the stroke, and the in-stroke of the piston expels the products of combustion from the cylinder.

2. Engines in which a mixture of gas or oil vapor and air is drawn into a pump forming part of the engine proper, and discharging the gas mixture into a receiver or reservoir in a state of compression. From this receiver the mixture enters the motor cylinder, being ignited as it enters. The ignition here does not increase the pressure, but increases the volume. The pump, say, puts one volume or cubic foot into the receiver ; ignition causes it to expand, while entering the cylinder, to two cubic feet. It does the work of two cubic feet in the motor cylinder, so that though there is no increase of pressure, there is nevertheless an excess of power over that spent in compression. The return stroke of the piston again expels the products of combustion.

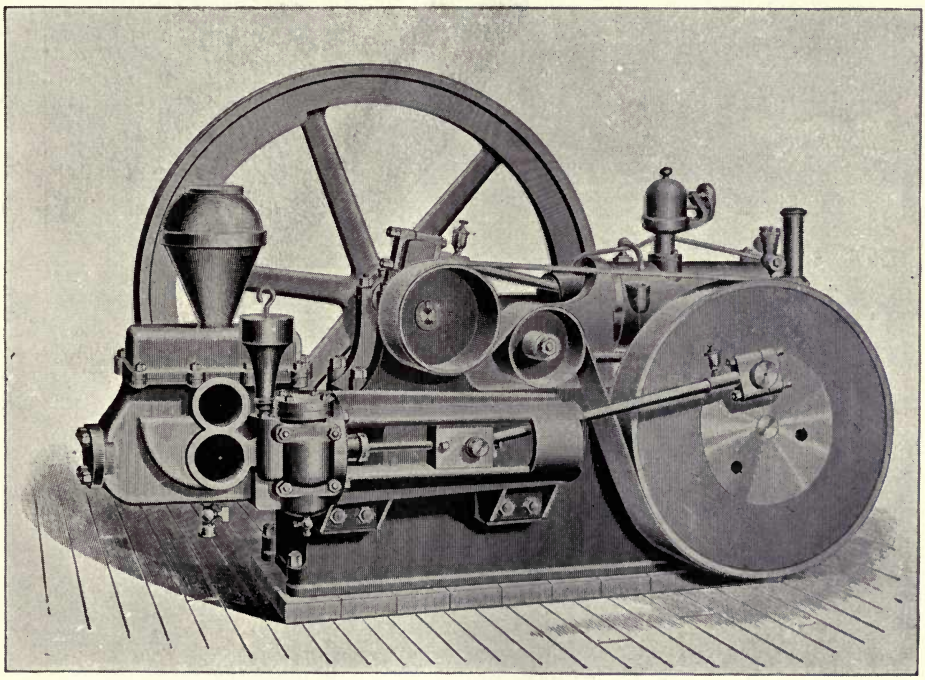


FIG. 4.—OTTO GAS ENGINE AND PUMP COMBINED.

3. Engines in which a mixture of gas or oil vapor and air is compressed, or introduced under compression, into the cylinder or space at the end of the cylinder, and is then ignited, the volume remaining constant and the pressure rising. Under this pressure the piston moves forward, and on its return as in

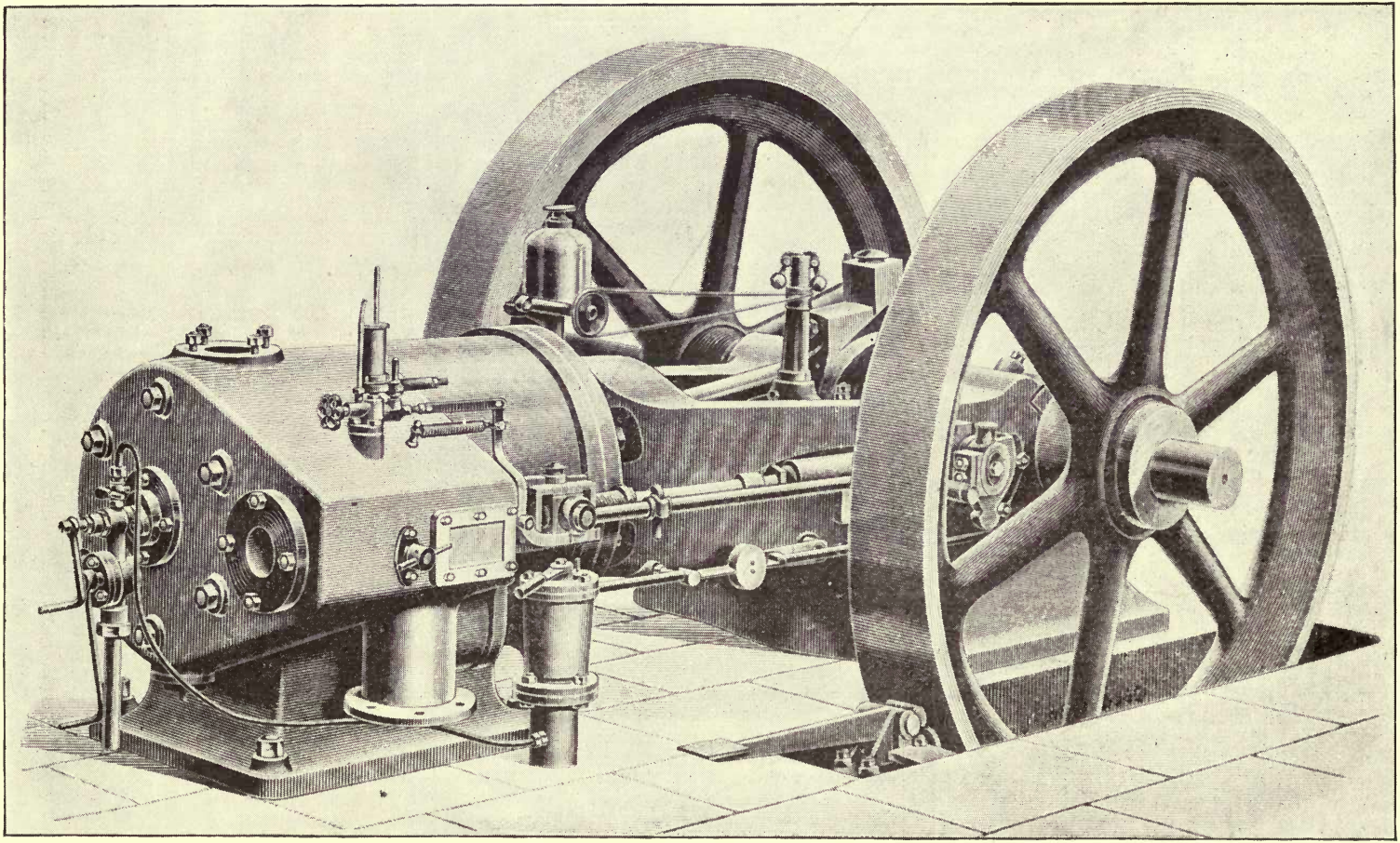


FIG. 5.—FIELDING'S GAS ENGINE, CONSTRUCTED BY MESSRS. FIELDING & PLATT, ENGINEERS, GLOUCESTER, ENGLAND.

the previous types, discharges the waste gases from the cylinder.

Types 1 and 3 are explosive engines, the volume of the gas remaining constant while the pressure increases. Type 2, on the other hand, is a gradual combustion engine in which the pressure is constant while the volume increases. The third type is generally regarded as the best kind of compression gas engine yet introduced, and by far the largest number of gas engines now in every day use are made in accordance with its requirements. The leading idea, compression and ignition at constant volume, was first proposed by Barnett in 1838, and later by several others, but Otto was the first to successfully apply it in 1876, in the now well-known engine bearing his name.

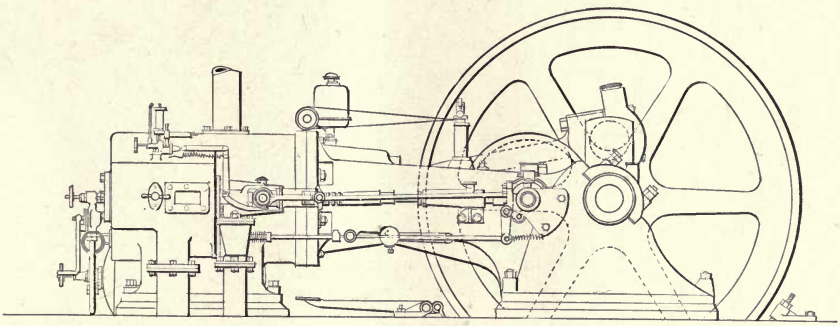


FIG. 6.—FIELDING'S GAS ENGINE. SIDE ELEVATION.

There still remains one important type of gas engine not included in this classification. It is the kind of engine known as the free piston or atmospheric gas engine already referred to above, and may be regarded as a modification of the first type. The first part of its action is precisely similar; the latter part differs considerably from it. In this engine the piston on moving forward, takes in its charge of gas and air from without at atmospheric pressure and temperature. When cut off it is ignited instantaneously, the volume being constant and the pressure increasing. The piston is not connected directly to the motor shaft, but is perfectly free to move under the influence of the explosion, like a projectile in a cannon, for example. It is thus shot forward in the cylinder, which is purposely made very long. The energy of the explosion gives the piston velocity, and the piston therefore continues to move considerably after the pressure has fallen by expansion down to atmospheric pressure. Owing to this and to the cooling of the gaseous products a partial vacuum is formed behind the piston till its whole energy of motion is absorbed in doing work against the pressure of the outside air. It then stops and the external pressure causes it to perform its return stroke, during which a clutch arrangement connects it with the motor shaft, giving the latter rotary motion. The piston during its return stroke proceeds completely to the bottom of the cylinder, expelling the products of combustion. This kind of engine was first proposed in 1854 by Barsanti and Matteucci, but Otto and Langen, as previously mentioned, in 1866, were first successful in overcoming the practical difficulties in its way, and many engines were built by them for practical uses. The engine though cumbersome and noisy, was a good and economical worker, and many are probably still in operation to-day.

It is scarcely within the province of this article to take up the theoretical considerations presented by these representative types of gas engines. Suffice it to say that the causes of the comparative efficiency of the modern gas engine over the older forms, such as the Lenoir and the Hugon engines may be

summed up in the one word "compression." Without compression before ignition an engine could not be produced which would furnish power economically and with small bulk.

To the prospective user of a gas engine, the question of cost of operation, or more specifically the cost of fuel used for a given amount of power is, as might naturally be expected, one of the first to present itself. That the fuel or gas cost is unduly great has been, and is still, a more or less prevalent impression and the fact seems to have been largely lost sight of by many power users that the development of the gas engine from what was at first perhaps little more than an interesting novelty to a source of even large powers at the present day has naturally brought with it much increased efficiency and correspondingly reduced running expenses. Just what these expenses are, so far as they are affected by the items of gas quality and cost, of course depends much upon special circumstances. The price of gas as well as its quality varies with locality and time, and definite statements of cost can therefore not easily be given.

Professor Ayrton, in England, several years ago, in comparing the fuel costs of gas engines and of portable and semi-portable steam engines to determine the relative expenses in driving electric light dynamos, estimated that the steam engines in question would, in a competition, consume about four pounds of coal per indicated horse-power per hour, but that in ordinary work their consumption would run up to six and seven pounds. Assuming a four-pound basis, however, which seems pretty fair, and taking, for the sake of illustration, the price of coal as $5 per ton, we get for the cost of a horse-power for fuel in these engines one cent per hour. At the rate for gas, paid in London at the time,—three shillings, or about seventy-five cents per thousand cubic feet,—the cost of one horse-power in the gas engine would amount to one and one-half cents per hour. Taking the highest prices paid in London for gas,—four shillings, or about one dollar per thousand,—the gas would cost two cents per horse-power per hour. This makes a very favorable showing for the gas engine, which has so many advantages and economies, as compared with the steam engine, as to easily overbalance its slightly higher fuel cost. In the United States, where the prices for gas are considerably higher, the comparison of the fuel costs would, of course, be somewhat less favorable to the gas engine. Much, however, is to be expected both here and abroad, in the direction of cheaper heating gas, and there seems little

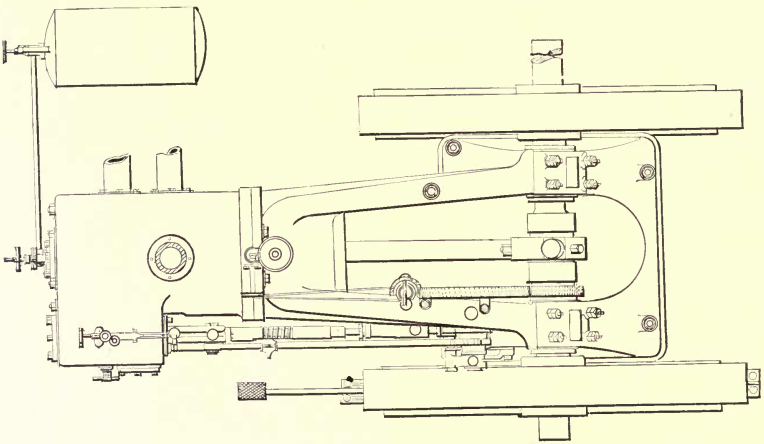


FIG. 7.—FIELDING'S GAS ENGINE. PLAN VIEW.

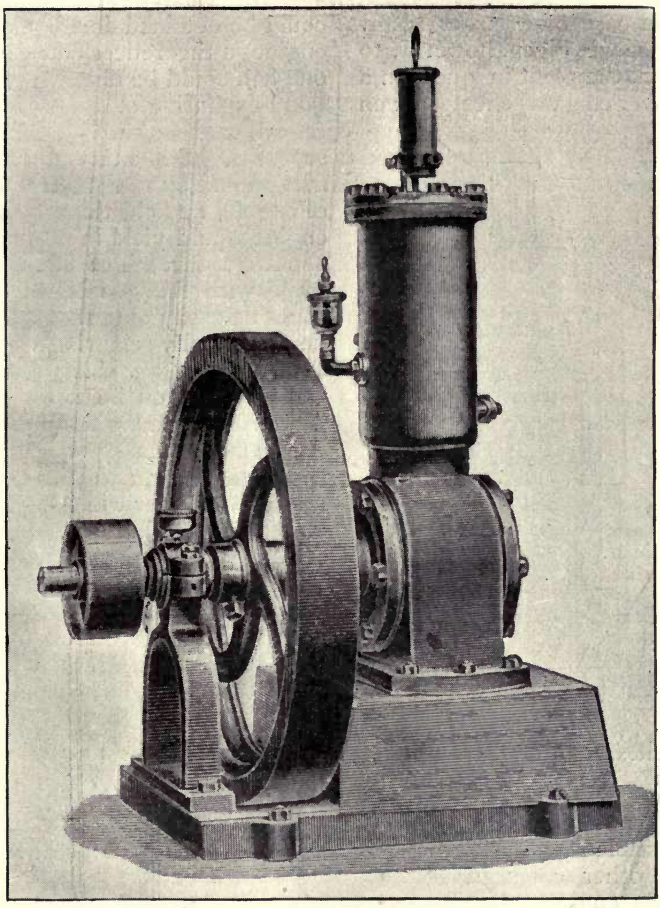


FIG. 8.—THE DAY GAS ENGINE. MESSRS. LLEWELLIN & JAMES, BRISTOL, ENG.

reasonable doubt that such a gas can be made and will probably be made in the near future, and will render the ordinary gas engine up to a certain size, much more economical in running expenses than an equal sized steam engine. Even as it is, however, with gas at the current rates, the gas engine in a great many cases foots up a smaller expenditure for a given horse-power than the steam engine. There is always a very considerable saving when standing still, and this, when the stoppages are frequent, may amount to a most appreciable total.

As a sample of what may be accomplished with a cheap heating gas we call to mind a low cost gas enterprise, started a number of years ago in the vicinity of New York City, by which heating gas was made on a large scale under the Strong patents. From figures that were received at the time it appeared that this gas had been used in an Otto engine at the rate of thirty-five cubic feet per hour for each horse-power. As the gas was produced at the rate of about twenty-seven cubic feet per pound of coal, it is easily seen that the engine was running on an equivalent of a little less that one and one-third pounds of coal per horse-power per hour. At the common retail price, the gas was worth fifty cents per 1000 cubic feet and there was every reason to suppose that the price could be reduced by a large per-

centage in the case of a larger plant. Ample evidence was given, however, to show that with the plant in question a great saving over coal was effected, even

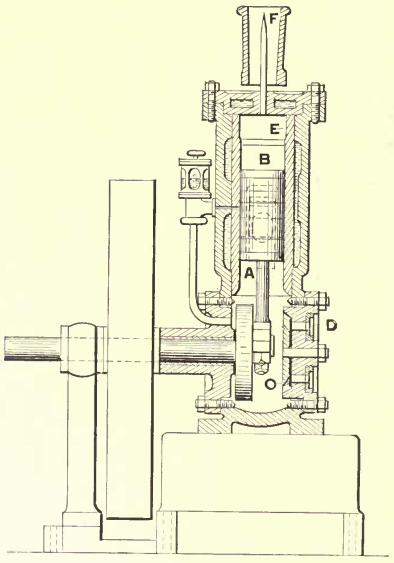


FIG. 9.—THE DAY GAS ENGINE. FRONT SECTIONAL ELEVATION.

though it did not produce the gas at the lowest possible rate.

In several other cases in England where Otto gas engines were supplied with cheap Dowson gas from Dowson producers specially erected for the purpose, it was found on test that the engines consumed on an average the equivalent of 1.2 pounds of coal per indicated horse-power per hour. These results at the time had not a little to do with the subsequent building in England of gas engines of comparatively high powers,—double-cylinder engines indicating in the neighborhood of seventy horse-power.

As to the possibilities of the uses of gas and its future as a source of power, it may not be amiss here to refer finally to one of C. William Siemens' addresses to the British Association for the Advancement of Science in which he expressed the conclusion that if a temperature of about 2732 degrees Fahrenheit and a pressure of four atmospheres could be obtained in an explosive gas engine, a theoretical efficiency of about one-half could be obtained, while with a good expansive steam engine the theoretical efficiency would be about two-sevenths. Deducting the losses by friction and by radiation in both kinds of engine, he held that the best steam engine would yield in mechanical effect about one-seventh of the heat energy, while with the gas engine one-fourth could be easily obtained. As a prediction he finally remarked that "before many years we shall find, both in factories and on board ships, engines with a fuel consumption not to exceed one pound of coal per effective horse-power per hour, and with these engines the gas producer will take the place of the steam boiler." This prediction, made a little more than ten years ago, has, as we all know, scarcely yet been fully realized though much progress has been made in the direction outlined,—how much, it is, in a measure, our

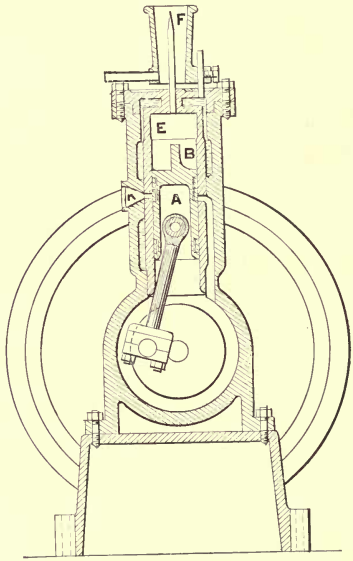


FIG. 10.—THE DAY GAS ENGINE. SIDE SECTIONAL ELEVATION.

object to show here by an exposition of the various gas and oil engines now in current use, doing a large variety of work.

THE OTTO GAS ENGINE.

It seems but rational and proper that we should begin our series of descriptions with an account of the Otto engine, or Otto "Silent" engine as it was called in its earlier days, since Mr. Otto, the first to succeed with the free-piston engine, was also the first to succeed in adapting compression in a reliable form, and since, further, it is to the utilization of this compression principle that the gas engine owes its present advanced state of development. The Otto engine belongs to the third type previously referred to, using a gaseous explosive mixture, compressed before ignition, and ignited in a body, so that the pressure increases while the volume remains constant. The power is obtained by expansion after the increase of pressure. It is interesting to note that the Lenoir and the Hugon engines were practically double-acting, there being two explosions for every revolution ; the Brayton engine is single-acting, there being one ignition of a charge for every revolution ; the Otto engine, however, is what may be termed only half single-acting, there being one explosion for every two revolutions of the engine.

The first of several designs of the engine, and one which is still looked upon as the standard form, has a single horizontal, open-ended cylinder. In this works a long trunk piston the front end of which serves as a guide. The cylinder is appreciably longer than the piston stroke, so that the piston, when full in, leaves a considerable space at the end of the cylinder into which it does not enter and which forms a compression chamber. Across the back end of the cylinder works a slide valve, controlling the admission and explosion of the charge, and held in place by a cover plate and strong, spiral springs. The valve is worked back and forth by a small crank on the end of a shaft parallel to the cylinder axis, and rotating at half the speed of the main crank shaft from which it receives its motion by bevel gearing. An exhaust valve and governing gear are also worked from this secondary shaft.

The engine cylinder serves alternately the purposes of motor and pump. During the first forward stroke of the piston, the admission valve is in such position that the gas and air mixture streams into the cylinder from the beginning to the end of the stroke ; the return stroke then compresses the mixture into the space at the back end of the cylinder. Meantime the slide valve has moved to another position, first closing the admission port to permit the compression of the charge, and then exposing a cavity in the valve in which there is a gas flame when the compression stroke is completed. The compressed charge is then ignited and under the influence of the resulting explosion the piston again moves forward. This constitutes the motive stroke. At the end of it the exhaust valve opens, and the return stroke drives out the burnt gases. The piston is then again in the position to take in a new charge for the next explosion. The cylinder is water jacketed.

A sectional plan of the original Otto engine is given in Fig. 1. In this A is the cylinder ; B, the piston ; C, the compression chamber ; the admission port shown extending through the cylinder head communicates alternately with the gas and air admission port E, and the flame port F, both of which are in the slide valve G. The latter, as already explained, is held in place by the cover J in which is carried the igniting jet R. The exhaust valve, which is a lift valve with a conical seat, is at K and is driven by the geared shaft M through a cam and lever, N and P. The main slide valve is also driven from this shaft in the manner clearly shown in the illustration. The governor with which the engine is provided is so arranged that when the speed goes above the normal rate it acts on a cam controlling the main gas supply valve and prevents its opening when the piston is drawing in air. To start the engine the igniting jet at R should be lighted, the gas supply turned on, and a few turns be given to the fly-wheel by hand. In some of the later types of Otto engine the admission slide valve G is replaced by a poppet valve design,

Fig. 2 showing one of the modern styles of larger size, indicating about sixty-five horse-power. In this later design, the igniting jet used in the earlier form of engine for exploding the gas charge has also given way to what is known as a tube igniter, or hot tube. This, as its name implies, is simply a wrought iron tube of small diameter, closed at one end. The open end is made to communicate with the engine cylinder by the valve arrangement. The tube is heated by a Bunsen gas flame within a non-conducting casing to prevent loss of heat, and the explosive gas mixture from the cylinder, entering the heated tube under pressure, becomes ignited. This method of ignition is at once simple and effective. The tube, moreover, is inexpensive and can be easily renewed when necessary.

The almost infinite variety of uses to which the engine may be put, and for some of which special designs are turned out, will not admit detailing here and we must content ourselves with the few examples shown. Thus, Fig. 3 shows a modern Otto engine applied to electric lighting, the sizes for this work ranging from fifty to 100 horse-power. Fig. 4 shows an engine and pump combination of the latest design in which gear wheels for driving the pump, as first used, have been entirely displaced by belting and correspondingly quiet running has been secured. Double-cylinder and vertical Otto engines are also on the market, all having their legitimate field of use.

THE OTTO GASOLINE ENGINE.

The poppet valve design has been adopted also in the Otto gasoline engine which has been on the market only a few years. This engine, like all oil engines, can be used where gas is not available, an advantage which has much to commend it and which in a measure explains the impulse which has been given to the oil engine industry during the past few years. In appearance and action the Otto gasoline engine is practically similar to the Otto gas engine, embodying as it does, only some minor valve modifications, and Fig. 2 may, therefore, be taken to represent it as well as its gas ally.

In this engine the gasoline is supplied from a tank which may be located outside the building, through a galvanized iron pipe with soldered joints, and provisions are made against any possible leak of the oil between engine and tank, or after it has reached the engine. The gasoline flows to the admission valve on the engine cylinder by gravity, and on being atomized or sprayed within the cylinder by a current of air, is at once fired either by an electric spark or by a tube igniter. Safety considerations may make the electric ignition method the preferable one, and this is therefore generally used.

While the gasoline engine can be used everywhere, and is not limited to exclusive use outside of cities because of possible gasoline vapor dangers, still the largest number of these engines have been placed in manufacturing suburbs not reached by city gas, and in the country. Like the gas engines, they are turned out in various designs for various kinds of work, and gasoline mining engines, electric light engines, portable engines mounted on trucks, etc., are now not uncommon.

Messrs. Schleicher, Schumm & Co., of Philadelphia, Pa., are the builders of both the Otto gas and the gasoline engines in the United States, the sizes of both types ranging from one-third horse-power upward. In England the Otto engine is made by Messrs. Crossley Bros., of Manchester, to whose design reference will be made in a future issue.

THE FIELDING GAS ENGINE.

The Fielding engine is made by an English firm, Messrs. Fielding & Platt, of Gloucester, the accompanying illustrations, Figs. 5, 6 and 7, showing one recently built and capable of indicating 100 horse-power at a speed of 160 revolutions per minute. The engine works upon what has become generally known as the Otto cycle referred to in the just-given description of the Otto engine as well as somewhat earlier in this article; but the arrangement of the valve gear embodies some new features. Fig. 5

gives a general view of the engine, while Figs. 6 and 7 show an elevation and a plan respectively.

The working charge is admitted and the waste products exhausted by means of a simple mitre-seated valve, through inlet and outlet ports controlled by the movements of a piston valve which receives independent motion from an eccentric, which also operates the timed ignition valve. The valves are placed horizontally by the side of the cylinder, an arrangement which permits of very straight and direct pipe connections for gas and exhaust, the air being drawn through the cylinder base, which acts as a muffle. The main mitre-valve is worked from a cam by a rod leading direct to the valve. The governor is of the high-speed, ball type acting upon a hit-and-miss gear interposed between the gas valve and its cam.

The importance of a starting gear for engines of such large size which cannot easily be turned over by hand is at once apparent, and due account has been taken of it in this engine by the provision of a new form of such gear patented by Mr. Fielding. This gear comprises a small reservoir of about the size of the cylinder jacket, which, after the engine has once been started, is charged with compressed air at a pressure of about fifty pounds per square inch by the engine itself when being stopped, thus utilizing the power stored up in the fly-wheels for use when re-starting the engine. The action of starting is as follows: The engine crank being placed slightly in advance of the dead centre nearest to the cylinder, gas is admitted by a small cock to the combustion chamber, from which the air is allowed to escape at a small pipe provided with

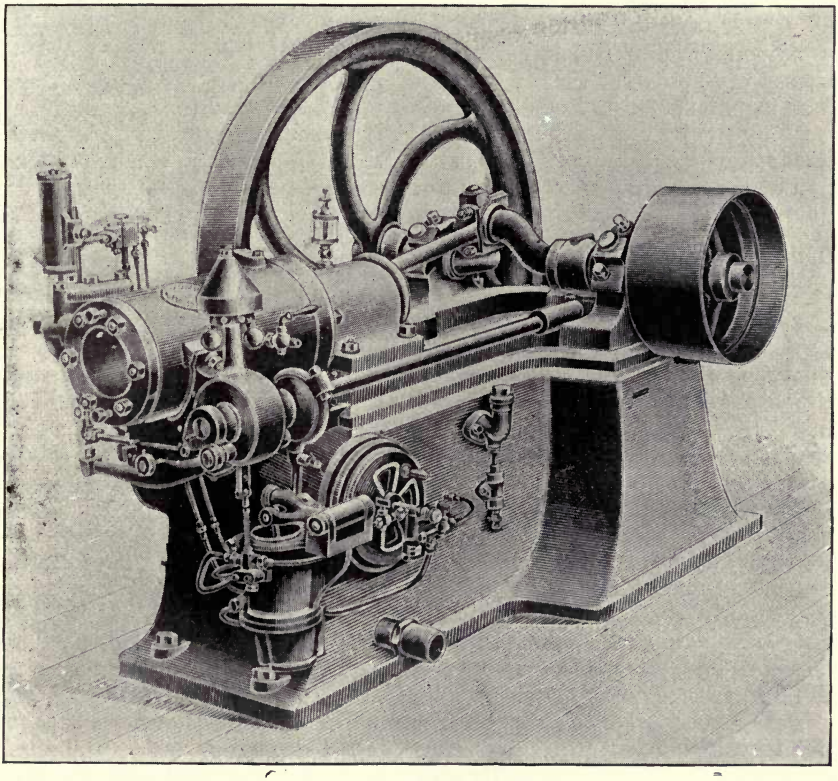


FIG. 11.—THE GRIFFIN OIL ENGINE, CONSTRUCTED BY MESSRS. GRIFFIN & CO., BATH, ENGLAND.

a stop-cock and terminating in a jet near the top of the tube igniter.

When the air has been driven out and the gas begins to escape at the jet, it becomes ignited, and as soon as it burns with a steady flame, showing that an ample supply of gas is present in the cylinder, the outlet and inlet cocks are closed. Compressed air is then turned into the cylinder, and the igniting valve being open, as soon as an explosive mixture is formed and sufficient pressure attained, the charge is ignited by the igniting tube, and the piston is driven forward with a powerful impulse, the ordinary cycle at once coming into operation. This method of starting is claimed by the builders to be so powerful that an engine can be started with partial load on, and any arrangement of fast and loose pulleys or friction clutch is thus entirely dispensed with.

THE DAY ENGINE.

The Day engine, shown in perspective and sectional elevations in Figs. 8, 9 and 10, is built by Messrs. Llewellin & James, of Bristol, England, and appears to have been designed with special reference to adaptability to domestic or other uses where the utmost simplicity and consequent ease of management by unskilled attendants are primary considerations. Few moving parts and an entire absence of what may properly be considered valve gearing are therefore the leading features of this engine. What moving parts there are besides the piston and fly-wheel are, moreover, completely hidden by a casing, so that the engine is simple in appearance as well as in fact. The crank chamber, as shown, is closed in and as the piston A rises a partial vacuum is formed underneath, and gas and air in proper proportion are drawn in through the passages D. These are controlled by a flap valve on the inside of the crank casing, and when the piston, after having reached the upper end of its stroke, begins to descend, this flap valve closes the gas and air inlets, and the completion of the down-stroke causes a slight compression of the explosive mixture in the crank chamber. At the end of the down-stroke a port opening at the side of the cylinder is uncovered by the upper end of the piston and through this the explosive mixture rushes into the cylinder proper above. In passing into the cylinder the gases impinge on the fin B on top of the piston and are thus deflected upward, displacing the products of combustion of the previously exploded charge, which pass out through the exhaust opening K (Fig. 10). The cylinder now is practically filled with an explosive mixture at atmospheric pressure. The piston, now again rising, cuts off both the supply and exhaust openings, and the mixture in the cylinder is compressed. When the piston reaches the upper end of its stroke, it drives the gas mixture into an ignition tube, F, and an explosion results.

It will be understood from this that there is one explosion for every double stroke or every revolution. A water-jacket keeps the cylinder cool. To start the engine, which obviously is made only in small sizes, it is simply necessary to give a few turns to the fly-wheel by hand.

THE GRIFFIN OIL ENGINE.

The Griffin oil engine, made by Messrs. Griffin & Co., of Bath, England, works with ordinary petroleum, either such as is used in domestic lamps, or with the cheaper and heavier varieties. This engine, too, works on the four-stroke or Otto cycle.

The points of novelty lie principally in the vaporizer, and in the burner for keeping the incandescent firing tube red hot. The vaporizer lies athwart the bed under the cylinder. It is a cast-iron vessel, surrounded with a passage for the emission of hot exhaust products from the cylinder, and provided internally with ribs to increase the heating surface. The oil enters it at one end, that shown in Fig. 11, in the form of fine spray, and is drawn out through the curved neck at the opposite end, Fig. 12, into the cylinder. In their passage the vesicles of oil become converted into vapor by the

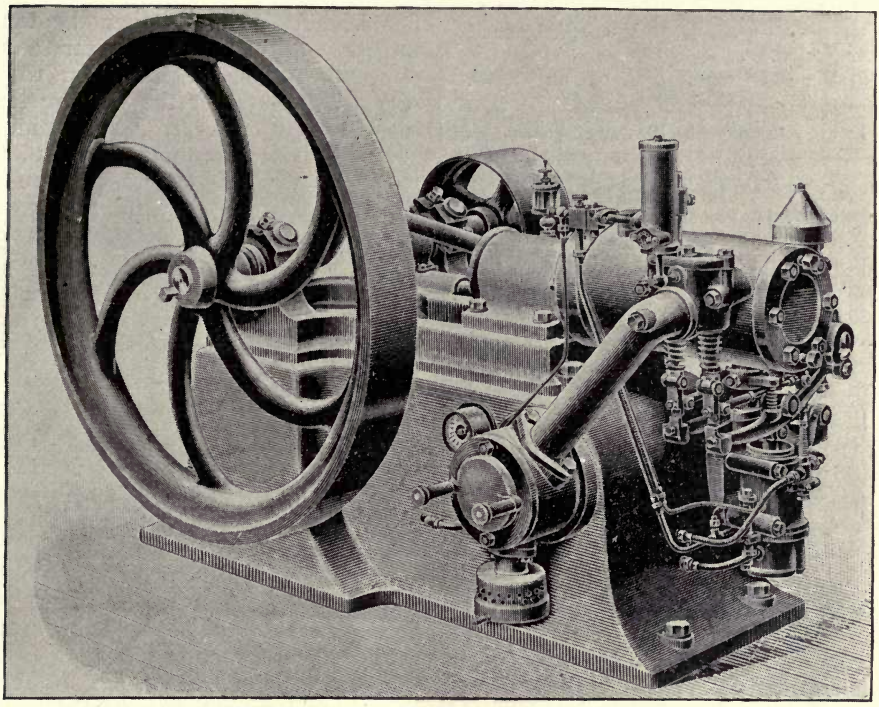


FIG. 12.—THE GRIFFIN OIL ENGINE.

heat of the walls, and shortly before the cylinder is reached they are mixed with additional air entering through the box to be seen below the bed. This air also has its temperature somewhat raised, as the inlet and exhaust passages run side by side in the curved end of the vaporizer leading to the cylinder. The spraying of the oil is effected by air compressed to twelve pounds on the square inch by a pump worked off the side shaft. The oil runs by gravity out of a reservoir in the bed, and is emitted through a fine tube into the air delivery nozzle. The blast picks it up, and, driving it forward, atomizes it at once. The flow of oil is regulated by the air jet itself; when the jet is cut off by the governor, the oil ceases to flow. This result is attained by means of a valve on the oil pipe. This valve closes naturally and is only opened by the air pressure; immediately this is admitted to the pipe the valve lifts and the air flows.

The heating of the incandescent tube is accomplished simply and ingeniously. The oil trickles into a tiny box and flows over a weir, which keeps it at a constant height. Two little wire pins stand in the oil at such a distance apart that the liquid creeps up between them by capillary attraction. On to the head of the column so raised, there impinges a fine air blast, which sprays the oil and carries it forward through a pipe to a Bunsen burner playing on the ignition tube. The pipe rapidly becomes heated by conduction from the burner and effects the vaporization of the oil, which burns like a gas jet, without odor.

The governor is of the centrifugal type and controls a hit-and-miss device. From this there is worked the admission valve, the exhaust valve, and the air inlet to the vaporizer, all being thrown in and out of action simultaneously. It is claimed as a feature of importance in the engine that all the valves are at rest when running light and operate only in direct proportion

to the work being done, thus saving wear and tear.

The vaporizer needs to be heated before the engine is started. A hand lever is supplied by which the air-pump is worked for ten minutes. The air is used to spray the oil, as if the engine were at work, but the jet is ignited as it enters the vaporizer and fills the latter with a powerful flame. A door is opened at the further end of the vaporizer and a temporary deflector fixed on to direct the flame under the passage leading to the cylinder. Ten minutes suffice to raise the temperature to the required extent. Up to the present time only small sizes of the engine have been built, but larger designs are under way.

(*To be continued.*)

THE UNITED STATES PATENT OFFICE.

By R. D. O. Smith.

I HAVE just read with interest Mr. Leon Mead's "Influence of Patents on American Industries," and regret that his examination should have been so brief. The cornerstone of our national prosperity is worthy of more exhaustive treatment.

In his first paper there are one or two errors which, while not momentous, still ought to be corrected. On page 117 he says: In the year 1812 the Patent Office was removed to a building purchased and repaired for the accommodation of the general post-office, and that said building stood on the site of the present post-office department building. Washington was captured by the British in 1814, consequently the episode and removal mentioned are placed at a date too early.

The building to which the Patent Office was removed was located where the so-called city hall now stands in Judiciary Square and not on the site of the present general post-office. When I went first to Washington in 1857 the city post-office was in a rickety old building on Seventh street, on ground now occupied by the general post-office. It had been standing there many more than twenty years.

There was saved from the fire of 1836 out of the records of the Patent Office but a single drawing. Patentees were invited to return their letters patent to the commissioner, who had the specifications copied into books and the drawings copied on sheets for the draftsman's room. Many of these reproduced drawings are models of artistic excellence.

But many patentees neglected to have their patents re-recorded. In fact, I presume but few except those whose patents were still young, or which had proved to be remunerative, responded. A great many who did respond also filed duplicate models.

At the fire of 1877 but few, if any, models of pending cases were lost, since models of pending cases are kept in the secret archives of the office, and mostly in the examiner's rooms. The fire did not extend beyond the north and west model rooms on the upper floor. None of the examiners had rooms on that floor at that time, and few, if any, of the paper records were lost. I believe there were some duplicate copies of the printed specifications which were burned, but none of the original records and none of the relics or other mementoes which were then preserved in the Patent Office, since all such were kept in the old or South Hall. The two burned model halls were the most spacious, and contained, I presume,

MODERN GAS AND OIL ENGINES.

By Albert Spies, Mem. Am. Soc. Mech. Eng.

Second Paper.

THE fact has already been briefly noted that not a few of the gas engines now on the market are adapted as well to the use of gasoline as to the use of gas proper, and that only a few slight modifications of design are sometimes necessary, and are provided for to permit changing from one fluid to the other. Such provision is made in the case of the Otto engine, as described in the preceding paper, and also in that of the Caldwell-Charter gas engine, built by the H. W. Caldwell & Son Company, Chicago, Ill., and shown in perspective and in sectional elevation, respectively, in Figs. 13 and 14. In both these views the engine is represented as arranged for the use of gasoline. In Fig. 14 *A* is the working cylinder ; *B*, the piston ; *C*, the inlet valve to the cylinder ; *D*, the mixing chamber ; *E*, a gasoline pump ; *F*, an air-gate worked by the rod *J*, which, in turn, is operated by the governor ; *K*, a gasoline supply regulating valve ; *H*, a gasoline tank ; *N N*, pipe from gasoline pump to a brass pan or reservoir, *P* ; *O*, a supply pipe from gasoline tank to pump ; *Q*, the ignition tube ; and *R*, the chimney surrounding it ; *I* and *L* are air suction pipes taking their air supply from the hollow base of the engine.

The pump *E* works constantly and keeps the gasoline in the small brass pan, *P*, which holds about a quarter pint, at a level fixed by an overflow pipe, which returns the surplus to the supply tank. The air-gate *F* is a brass plate, having two holes so arranged that in normal position a free passage of air is allowed through pipe *I*. When the governor opens the air-gate, the pipe *I* is closed and the air is sucked through pipe *L*. In this pipe is a nozzle leading to the pan *P*, and the passing air draws from nozzle the proper amount of gasoline and forms a combustible mixture of gasoline and air. Each suction takes fresh gasoline from the reservoir, always the same quantity as controlled by supply or throttle-valve *K*, and the charges of gas are therefore of equal strength and value. The ignition tube *Q* is kept at a uniform heat by a simple gasoline burner, furnished with engine. This tube is surrounded by the asbestos-lined chimney *R* which retains the heat. The governor is arranged on the crank-shaft, and through the rod *J* operates the air-gate *F* as already intimated. The exhaust valve, shown at the side of the cylinder, is controlled by a spring and a rod, receiving motion from the larger of two gear wheels. This gear wheel, as will be understood, is twice as large as the smaller driving pinion on the main shaft, and, therefore, makes only half as many revolutions as the latter, thus, of course, opening the exhaust valve only once in every two revolutions of the shaft. The engine, it would seem almost unnecessary to state, works on the Otto cycle. A water jacket, as usual, surrounds the cylinder. The engine, when intended for the use of gas instead of gasoline,

dispenses with the gasoline pump and tank, and one of the suction pipes is connected with a gas supply pipe, in which a gas valve is located. It will be seen, therefore, that at a slight expense the gasoline engine can be changed to a gas engine, or *vice versa*.

A 95 indicated horse-power Caldwell-Charter gasoline engine, developing 65 actual horse-power, is now furnishing power for a large grain elevator at Camden, N. J., and is said to give entire satisfaction. For such large engines the makers supply a self-starter, consisting of a hand pump for forcing a charge into the cylinder, and a detonator for exploding the charge after it has been introduced. This gives the engine its first impulse, after which it continues to operate with its automatic gear.

The Roots engine is built by the Roots Economic Gas Engine Company, London. It works on the Otto cycle, there being one explosion for every two revolutions, but the compression of the gas and air mixture is effected in a novel manner, which constitutes the chief feature of the engine. Figs. 15 and 16 represent a perspective view and sectional elevation respectively. The admission valve, shown on the left of Fig. 16, opens into a special compression chamber. No special gas valve is used, the supply being adjusted by suitably proportioning the gas inlet. To make the manner of working clear, we will assume that one working cycle has just been completed. By studying the sectional view it will then be understood that on the next upward stroke of the piston, or on the suction stroke, the air and gas are drawn in through the admission or suction valve, which opens automatically, and displace whatever products of combustion may be in the compression chamber. The latter is thus filled with

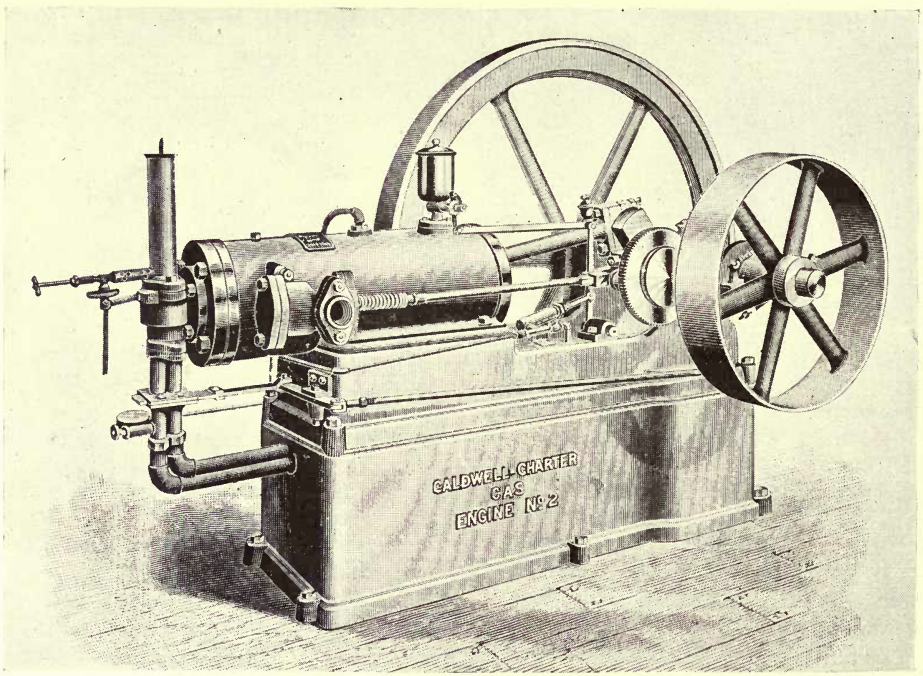


FIG. 13.—THE CALDWELL-CHARTER GAS ENGINE. BUILT BY THE H. W. CALDWELL & SON COMPANY, CHICAGO, ILL.

a rich mixture of gas and air, only a small proportion of which enters the working cylinder through the port *a*. This cylinder, therefore, at the beginning of the first down-stroke, contains a rather dilute mixture of fresh gas, air, and burnt gases, which, as well as the rich charge in the compression chamber, is compressed when the piston descends. Before the piston has gone down very far, however, it passes over the port *a*, cutting off communication with the compression chamber, and during the remainder of the stroke only the dilute mixture in the cylinder is further compressed. At the end of the stroke this mixture is fired by a tube igniter shown at the right. The pressure rapidly rises and the piston commences its working stroke. After having gone a short distance it uncovers the port *a* leading to the compression chamber, and the rich charge there is further compressed under the influence of the explosion of the weak charge, and is fired. Just how this manner of working affects the diagram is shown in Fig. 17, which is a sample indicator card. After the first explosion, it is seen, the pressure begins to fall, and when the port *a* to the compression chamber containing gas at a low pressure begins to open, this fall is accentuated, but very soon the fresh charge in the chamber is fired, and the pressure line rises again, and is well maintained for a considerable proportion of the stroke. At the end of the working stroke the exhaust valve is opened by the action of an eccentric.

The peculiar system of compression is claimed by the makers to effect a considerable economy of working, the degree of compression in the special chamber amounting to about 120 pounds per square inch. This is considerably more than is ordinarily attained in gas engine compression.

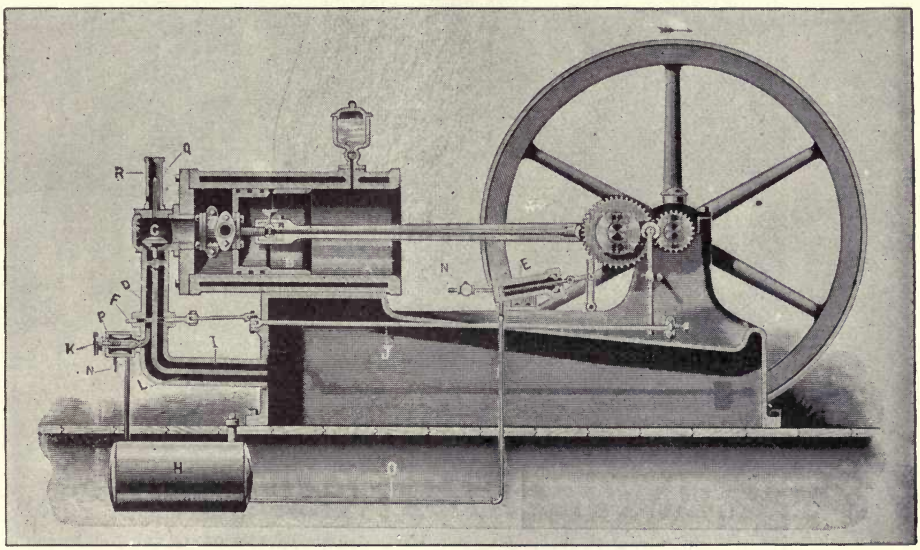


FIG. 14.—SECTIONAL ELEVATION OF THE CALDWELL-CHARTER GAS ENGINE.

A novel form of gas engine built by the Palatine Engineering Company of Liverpool, England, is shown in Figs. 18, 19 and 20, which represent vertical sections and an elevation. The engine is of the vertical type, and the crank and connecting rod are completely cased in. An air inlet valve admits air into the enclosed space when the piston descends. This air is slightly compressed

on the up-stroke, and when the piston reaches the top of the stroke, a quantity of this compressed air rushes into the cylinder through air blow—through ports, the cylindrical part of the piston being then above these ports—see Figs. 18 and 19. At this moment the exhaust valve is opened by the lever *L*, close to the gas admission. The gas is taken into the gas pump, Figs. 19 and 20, and the quantity admitted is determined by the governor and detent, Fig. 19, which control the admission of the gas to the pump by means of the small gas valve.

Ignition of the charge is effected by

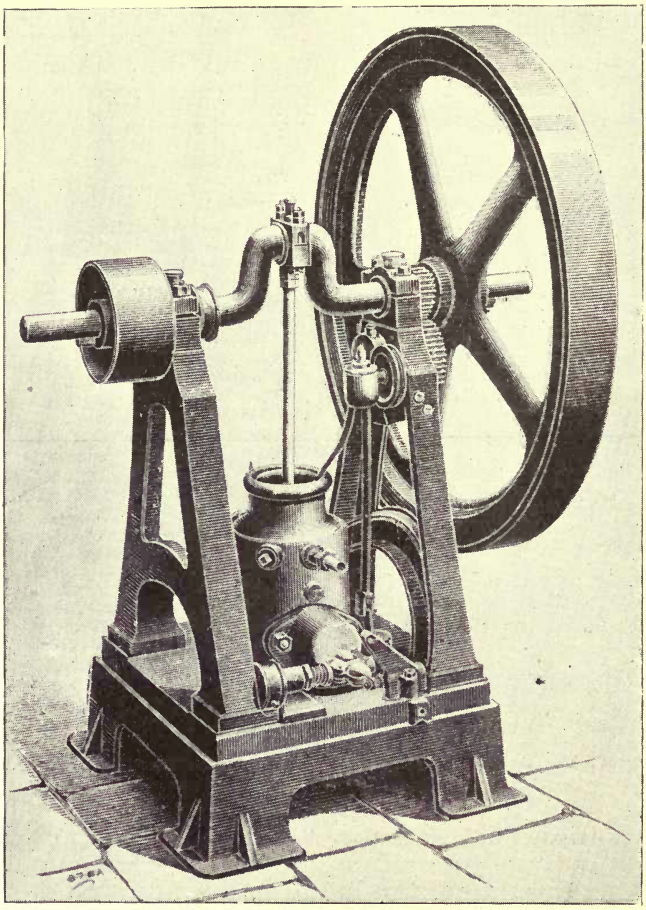


FIG. 15.—THE ROOTS GAS ENGINE. BUILT BY THE ROOTS ECONOMIC GAS ENGINE CO., LONDON, ENG.

Fig. 20, which is operated by one of the cams on the spindle driven by the wheel *W*. The cylinder is thus completely swept out by a charge of fresh air. Referring to Fig. 18 it will be seen that the air suction valve is placed in the space below the cylinder and a tube igniter, *I T*, and the moment at which the charge is permitted to enter the tube is controlled by a valve *I V*, worked by the lever *L*, Fig. 20. The engine, it will be noted, works on the Otto cycle.

The Campbell engine, made by

the Campbell Gas Engine Company, London, shown in Fig. 21, is designed to work according to a cycle in which there is an explosion at each revolution,

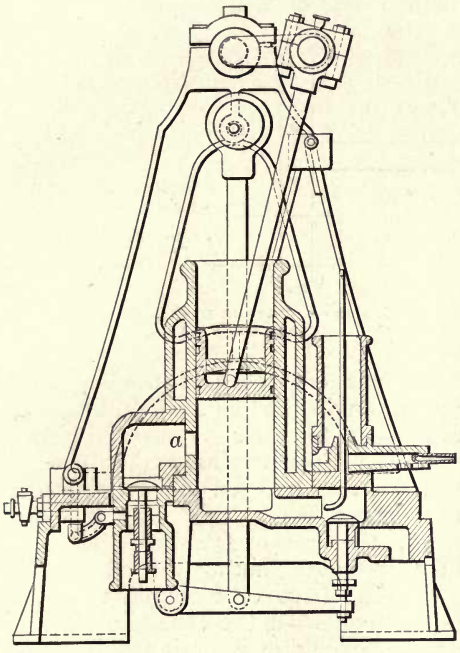


FIG. 16.—SECTIONAL ELEVATION OF THE ROOTS ENGINE.

twice as many, therefore, as in an engine working on the Otto cycle.

This effect is attained by taking in the charge of gas and air by means of a pump, instead of by the action of the main piston. This pump is driven off a crank-pin in the side of the flywheel,

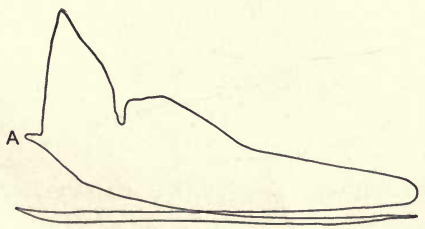


FIG. 17.—INDICATOR CARD FROM ROOTS ENGINE.

and draws in gas and air through ports, controlled by a slide valve. There is a straight connection between the pump and the working cylinder, interrupted only by a simple non-return valve. The compressing action of the pump on the back stroke is so timed that the mixture attains a pressure of

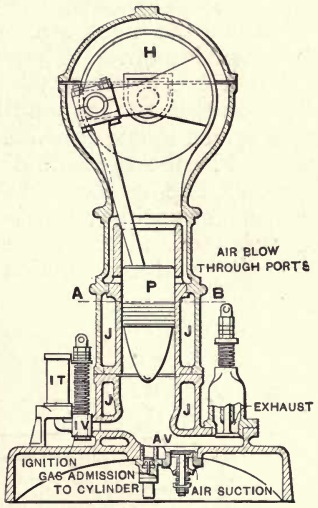


FIG. 18.—VERTICAL SECTION OF THE PALATINE GAS ENGINE. BUILT BY THE PALATINE ENGINEERING CO., LIVERPOOL, ENG.

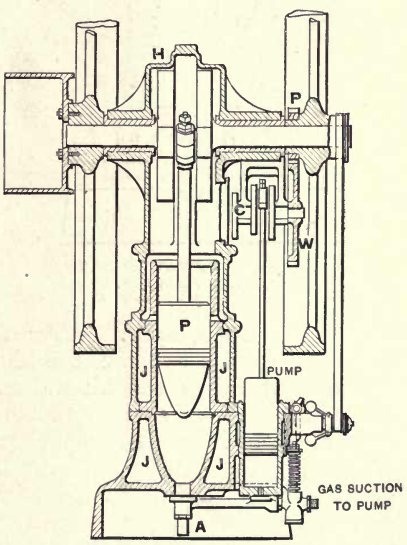


FIG. 19.—FRONT SECTIONAL ELEVATION OF THE PALATINE ENGINE.

from six to ten pounds, just as the main piston passes an exhaust port in the side of the cylinder, and allows the expanded, acting charge to escape. The

new charge then lifts the valve and enters the cylinder, driving the remaining products of combustion before it through the exhaust valve. On the return stroke of the main piston the charge is compressed, and at the commencement of the next stroke it is fired by a tube igniter.

The slide valve by which the admission of gas and air to the pump is controlled, is driven in one direction by an eccentric and in the opposite direction by a spring. The connection with the eccentric is not positive, but between the eccentric rod and the valve is interposed a hit-and-miss motion under

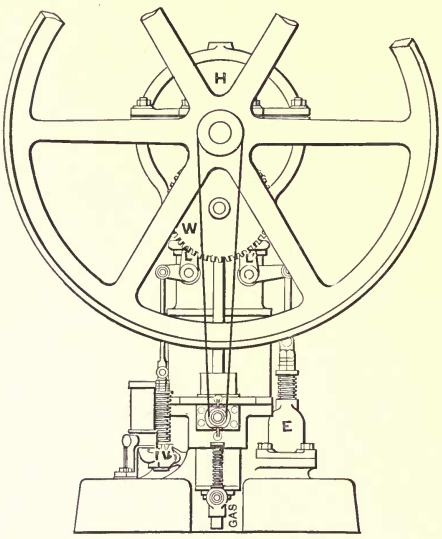


FIG. 20.—SIDE ELEVATION OF THE PALATINE ENGINE.

the control of a governor. When the speed of the engine becomes too high, the governor raises the hit-and-miss device, and the valve is either not opened at all, or is opened only slightly, depending upon the position of the stepped piece, shown in Fig. 22. When the engine is permanently on light work, the amount of the gas and air charge can be reduced by setting the eccentric further around, and the strength of the charge can be graduated by means of a cock on the inlet pipe.

The several indicator cards, Fig. 23, clearly show the effect of igniting gas mixtures of varying quantity in the engine. So far as structural features are concerned, it will be noticed from the perspective view of the engine that the cylinder does not overhang, as in

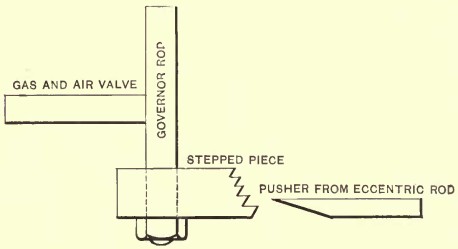


FIG. 22.—GOVERNOR DETAIL OF THE CAMPBELL ENGINE.

most gas engines, and the cylinder jacket, engine bed and crank bearings are all cast together in one solid piece.

In the Foos engine, either gas or gasoline may be used indiscriminately, the design being the same in both cases, the use of gasoline, however, of course necessitating the addition of a gasoline tank or carburetor to the outfit as shown in the general view, Fig 24. The engine is designed to work on the Otto cycle, there being ordinarily one explosion in the cylinder at every second revolution, or fourth stroke.

We will assume, by way of explanation, that the piston is making the first stroke of a cycle, or that, in other words, it is descending and sucking in

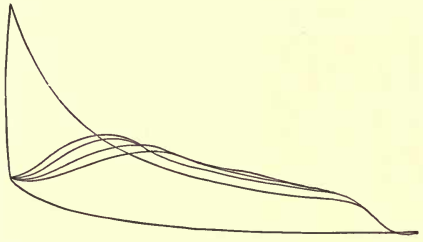


FIG. 23.—CAMPBELL ENGINE INDICATOR CARDS.

the explosive charge. The gas then goes to the engine through the valve *O*, and mixes with air coming through the branch pipe and valve *N*. The gas and air mixture passes on through the governor valve *M*, ascends in the

vertical pipe shown at the left of the engine, passes through the check valve *P*, and enters the exploding chamber *B* through a lift valve, which ordinarily is kept down on its seat by a spring, *C*, but which opens automatically under the influence of the partial vacuum formed in the engine cylinder during the suction stroke. When gasoline is used instead of gas, air is drawn through the gasoline tank or carburetor, entering at *U*, and in its passage it absorbs sufficient gasoline vapor to make it ignitable. Warm air is used to absorb the gasoline, being led to the tank pipe *U* through the rubber hose shown in dotted lines. This hose is connected to a small drum, *J* on the exhaust pipe *A*. The drum is perforated so as to admit air which, in passing around the exhaust pipe is warmed. The gasoline vapor coming from the carburetor passes through the check valve at *R*, at the outlet end of the tank, and then on to the engine as just described. The engine cylinder and chamber *B* having been filled with the explosive mixture, the piston performs its upward or compressing stroke, during which the charge is compressed. At the beginning of the next down-stroke ignition of the charge is effected in the exploding chamber *B* by an electric spark, caused by the contact and immediately following separation of the inner ends of the two electrodes, *D* and *E*. The arrangement of these will be better understood from Fig. 25. When the two ends *X* and *Y* are brought together, as shown in this illustration, the electric current from the battery provided with the engine is closed, and when they are then quickly separated, a spark is produced, and the gas or vapor charged is exploded.

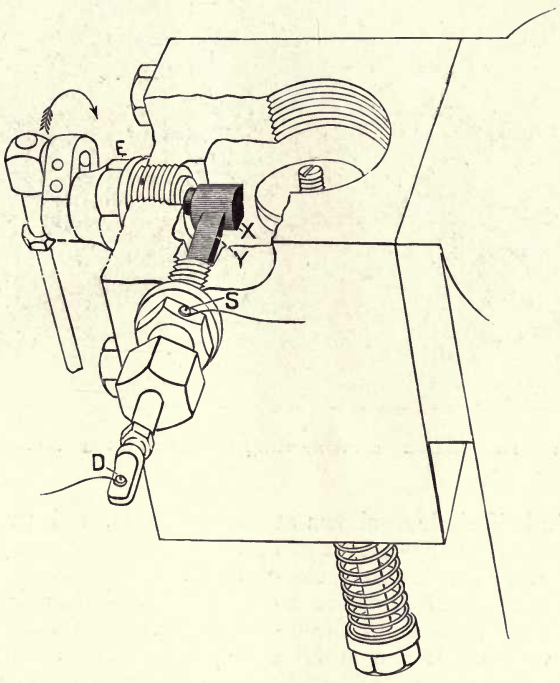


FIG. 25.—IGNITING ELECTRODES OF THE FOOS ENGINE.

The connection and separation of the points of the electrodes is caused by the revolving motion of electrode *E*, Fig. 24, the end of which is made

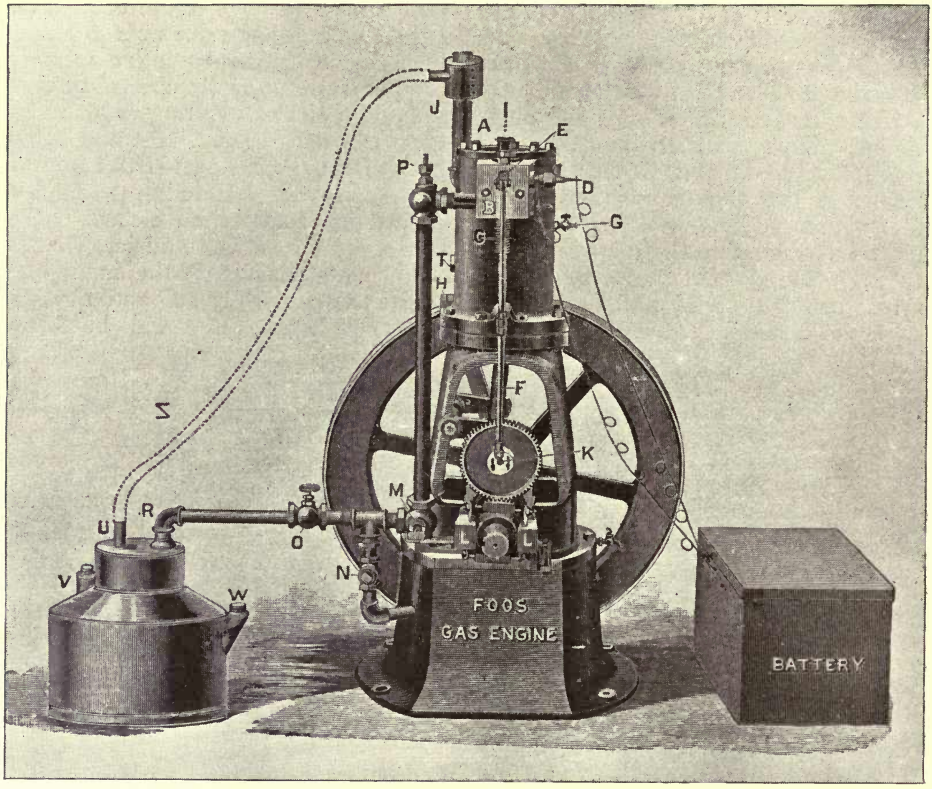


FIG. 24.—THE FOOS ENGINE. BUILT BY THE FOOS GAS ENGINE CO., SPRINGFIELD, OHIO.

in the shape of a half circle as shown at *X* in Fig. 25, bringing the points *X* and *Y* together at every revolution of electrode *E*. Electrode *D* is made to screw further in so that when the inside end *Y* is worn off it can still be kept in contact with electrode *E* at *X*. Care must be taken not to screw it in so far but that there will be a separation of an eighth of an inch between the points of the two electrodes at every revolution of electrode *E*. The latter is worked from the main shaft through the intervention of two gear wheels and the rod *f*, the secondary gear wheel *K* being twice the size of the one mounted on the driving shaft, and, hence, making only half as many revolutions. It follows, therefore, that the electrode end *X* (Fig. 25), will revolve once for every two revolutions of the engine shaft, and, accordingly, will produce an igniting spark once for every two such revolutions.

The explosion having taken place the piston is forced down, making its working stroke, and on the next upstroke the products of combustion are expelled from the cylinder through the exhaust valve and pipe *A* at the back of the cylinder. The exhaust valve, which is of the lift type, is worked by a cam on the spindle of the gear wheel *K*, and by a rock-shaft connection. This valve, which is fitted with a spring to bring it firmly back to its seat after having been opened, and the governor valve *M* are the only valves in the engine which receive positive motion from the engine shaft.

The governor is of the centrifugal type, and is mounted on the crank shaft. Its revolving weights are shown

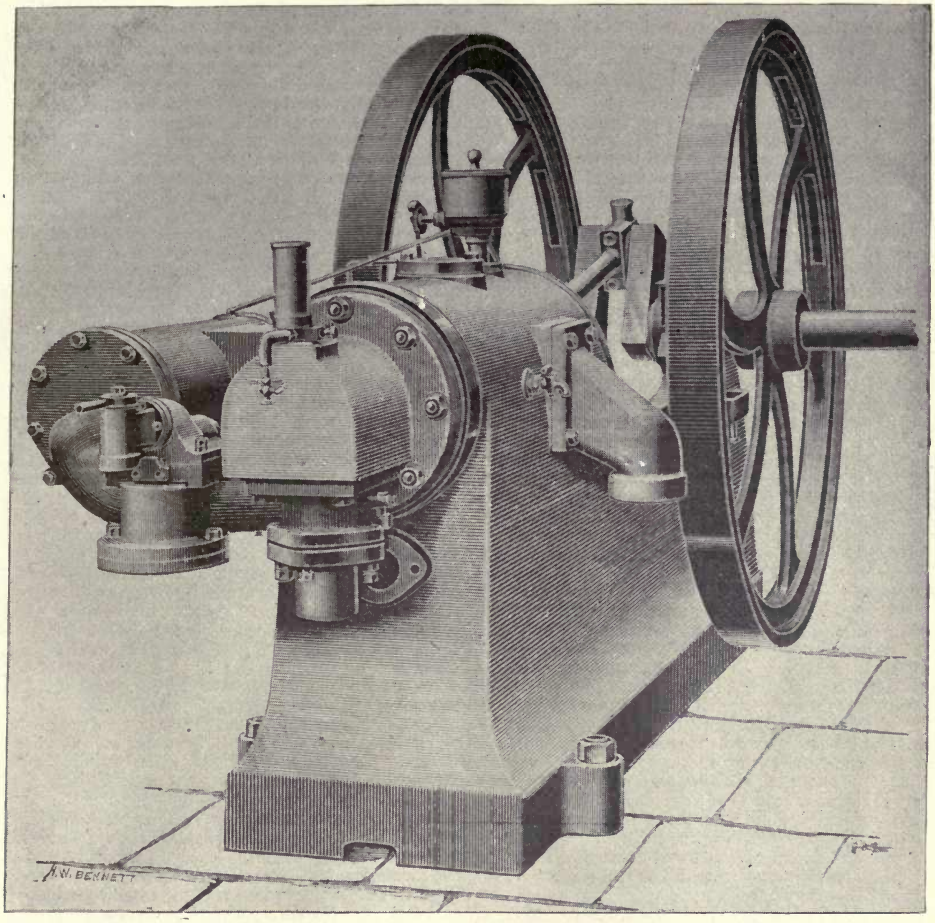


FIG. 21.—THE CAMPBELL GAS ENGINE. BUILT BY THE CAMPBELL GAS ENGINE CO., LONDON, ENG.

at *L L*. These, it will be noted, revolve in the same plane as the fly-wheel, and, when the normal speed is exceeded, fly outward and move a lever controlling the position of the valve *M*, and cutting off or reducing the supply of explosive mixture.

The engine has the usual water jacket to prevent over-heating of the cylinder. In Fig. 24 the inlet and outlet pipes for this jacket are marked *H* and *I*; *G* is a stop-cock for the escape of compressed gas, and is to be opened when starting up; *T* is an oil cup connection; *V* is a float in the gasoline tank to indicate the level of the fluid, *W* is the feed opening for tank.

The engine is built by the Foos Gas Engine Company, of Springfield, Ohio, the range of sizes being from two to ten horse-power.

The Priestman oil engine is made both in the United States and England, Messrs. Priestman & Co., of Philadelphia, the American builders, turning out the design shown in Fig. 26, while the English builders, Messrs. Priestman Bros., of London and Hull, have for their latest type of engine the one illustrated in Fig 27. The engine uses for fuel common petroleum such as is burned in lamps, and the quality best suited to this purpose is just what is safest in common use, that is, the highest proof oil. A sprayed jet of this oil is first broken up by compressed

air playing on it in a special nozzle, and then it is further mixed with air, heated and vaporized by the hot products of combustion from the exhaust which are led around a vaporizer or mixing chamber before being allowed to escape. This might be called a regenerator. The oil vapor thus thoroughly mixed with air in proper proportions is drawn through an automatic suction valve into the engine cylinder by the piston in its forward stroke. On the return stroke this change is compressed to about half its bulk, and on the next forward stroke it is ignited electrically producing the working pressure. At the end of this working stroke, as it may be called, an exhaust valve opens and permits escape of the products of combustion during the succeeding return stroke, thus completing one cycle which, it will be observed, is the same as in the Otto engine, and to which frequent reference has already been made as the Otto cycle. The oil is burned precisely as it would be burned in the wick of an oil lamp, and all the oil is so burned, except that in contact with the comparatively cool surfaces of the water-jacketed cylinder. Upon these cooler surfaces, the oil not burned is condensed and furnishes the means of lubrication. As in many other engines of this type, there is in the Priestman engine a space at the back end of the cylinder over which the piston does not sweep in its motion. This space, or compression chamber, bears a fixed proportional relation to the whole cubic contents of the cylinder, and acts as the furnace and boiler that is to operate the engine, being, in fact, the seat of power of the machine.

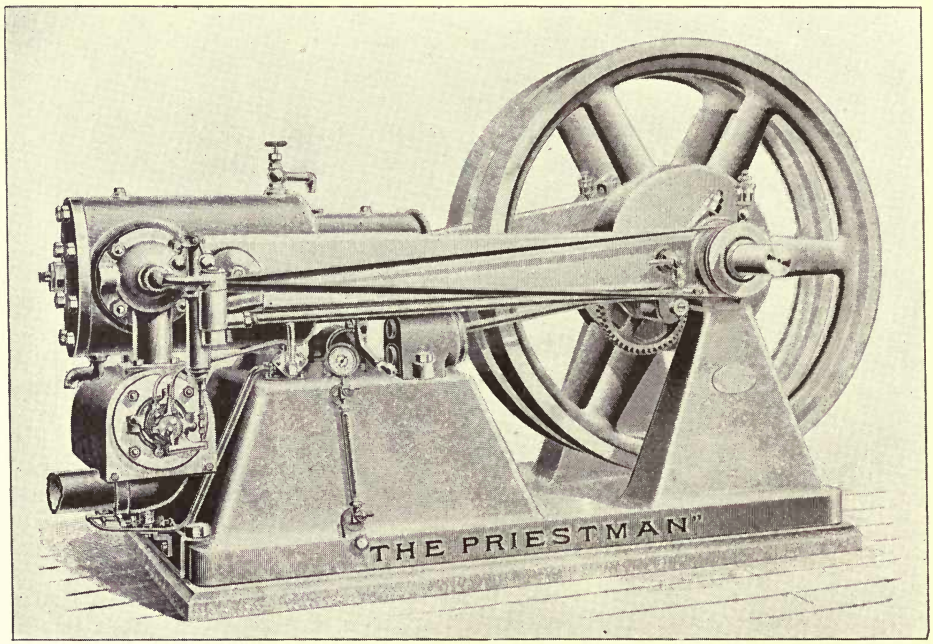


FIG. 26.—THE AMERICAN PRIESTMAN PETROLEUM ENGINE. BUILT BY PRIESTMAN & CO., PHILADELPHIA.

Fig. 27, as already remarked, shows the latest type of the English Priestman engine. This differs from the earlier English design in that the various working parts have been made more accessible, and at the same time have been somewhat simplified. As the illustration shows, the hand pump,

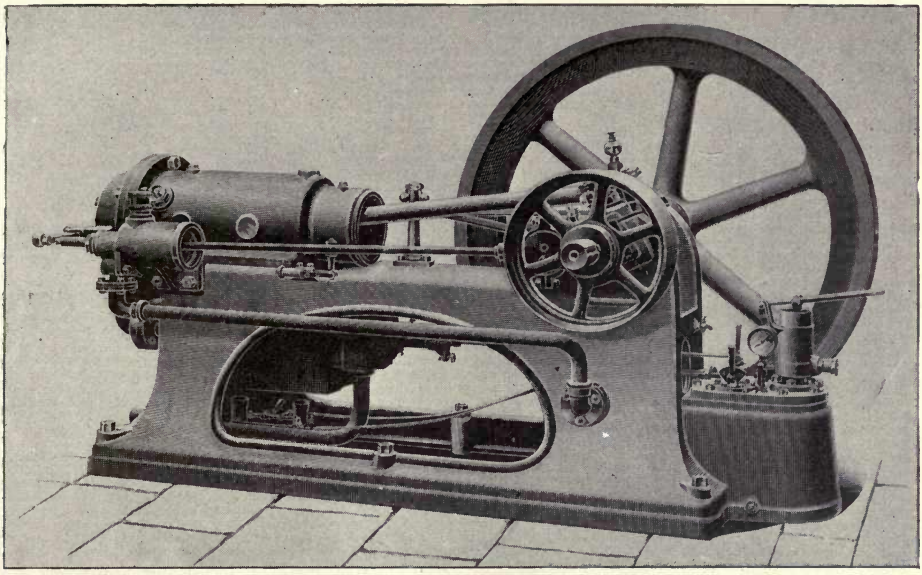


FIG. 27.—THE ENGLISH PRIESTMAN PETROLEUM ENGINE. BUILT BY PRIESTMAN BROS., LONDON, ENG.

by means of which air is compressed into the oil chamber preparatory to starting the engine, is now fitted on an extension of the engine frame in place of being concealed inside this framing, as in the old type. The air pump is also now arranged to be driven by the same a minimum of trouble. In all other points the engine is similar to the old type, the action of which has already been outlined.

In the American design, shown in Fig. 26, the idea of making all the parts readily accessible has been still

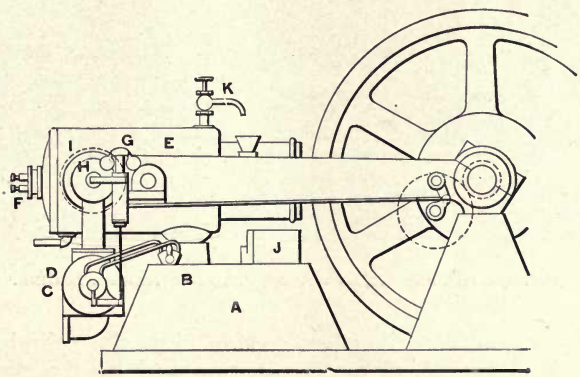


FIG. 28.—EXPLANATORY DIAGRAM OF PRIESTMAN ENGINE.

eccentric-rod as that which operates the gas valve and firing gear, in place of being driven by a separate rod as formerly. The wide opening in the frame permits of the vaporizer and spray maker being got at in case of need with further carried out; hence, the immediately striking difference of appearance. All the main features of the engine are, however, practically the same. In the English engine, it will be noticed, the fly-wheel is placed out-

side of the bearings, and the shock from the sudden ignition of the charge thus comes upon the crank. With the principle adopted in the American design, it is argued that the two flywheels which are used instead of one, and which form part of the crank, offer their great weight to the blow between the bearings and present a mass of

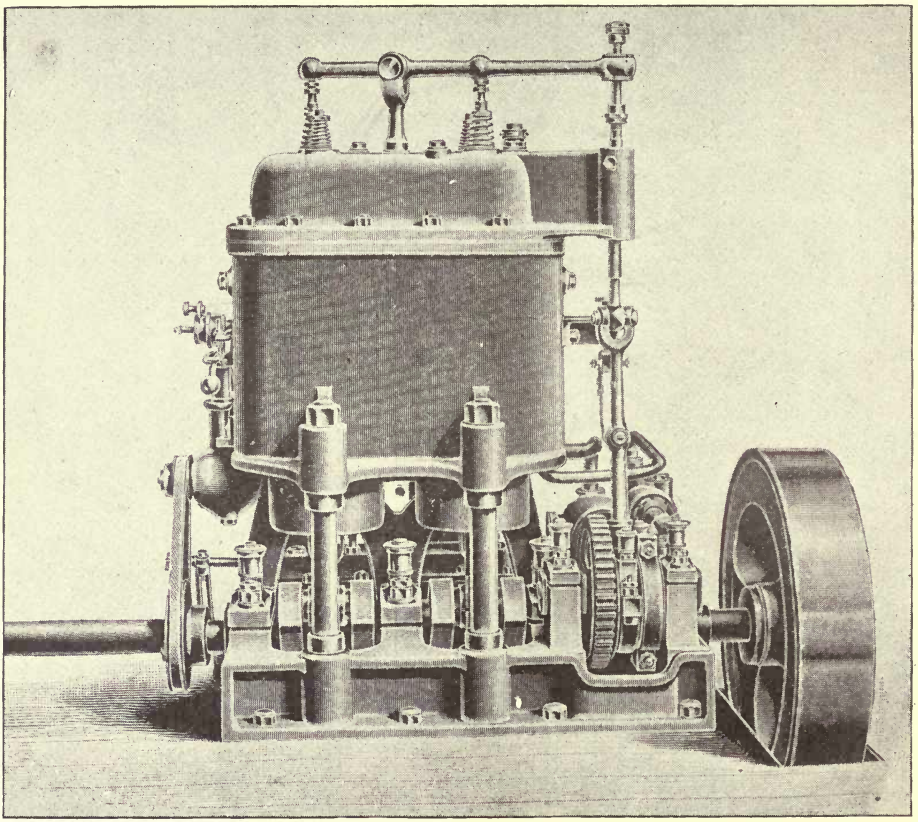


FIG. 29.—THE PRIESTMAN DOUBLE CYLINDER MARINE ENGINE.

sufficient inertia to neutralize the effect of this blow.

The diagram shown in Fig. 28 more clearly explains the operation of the engine. In this illustration, *A* represents an oil tank filled with any ordinary high test (usually 150 degrees test) oil, from which oil under air pressure is forced through a pipe to the three-way cock, *B*, and is thence conveyed to the atomizer *C*, where the oil is met by a current of air and broken up into atoms and sprayed into the mixer *D*. It is there mixed with the proper proportion of supplementary air and sufficiently heated by the exhaust from the cylinder passing around this chamber. The mixture is then drawn by suction through the inlet valve *I* into the cylinder *E* where it is compressed by the piston and ignited by an electric spark passing between the points of the ignition plug *F*, the current for the spark being supplied from an ordinary battery furnished with the engine. The governor *G* controls the supply of oil and air proportionately to the work performed. The burnt products are then discharged

through the exhaust valve *H*, which is actuated by a cam. The inlet valve *I* is directly opposite the exhaust valve. The air pump *j* is used to maintain a small pressure in the oil tank to form the spray. *K* is the water jacket outlet.

The engine at the Philadelphia works is now made in four sizes, ranging from five to twenty indicated horse-power.

One of the various applications of the Priestman engine has been made by the English builders to the propulsion of a launch which, last year, was running on the river Thames, where she aroused considerable interest. The boat was thirty-six feet long by seven feet three inches beam, by four feet six inches deep. A ten horse-power engine of the marine type, illustrated in Fig. 29, was used, there being two cylinders each nine inches in diameter by nine inches stroke. In principle the engine was the same as the regular Priestman oil engine, the oil being sprayed by a jet of compressed air and afterward heated in a vaporizer kept hot by the exhaust gases. The ignition also was effected electrically, a battery being used to give the spark. The valve gear in the engine, as shown, is very simple. The inlet valves on top of the cylinders act automatically.

The engine was placed amidships and occupied very little space as compared with machinery and boiler space of a steam launch. The speed of revolution was controlled by a governor which cut off a part of the charge according to the amount of work to be done, and the engine was slowed down when required by depressing the governor spindle by hand. The normal speed was 240 revolutions per minute, giving the boat a speed of about nine miles an hour. In this marine type of engine the motion is in one direction only, and reversing is effected by means of a friction clutch which also admits of running the engine detached from the propeller. The boat was easily handled and the machinery required very little attention. About forty gallons of oil, sufficient for several days' running, were carried in the bow, from which the engines drew their supply.

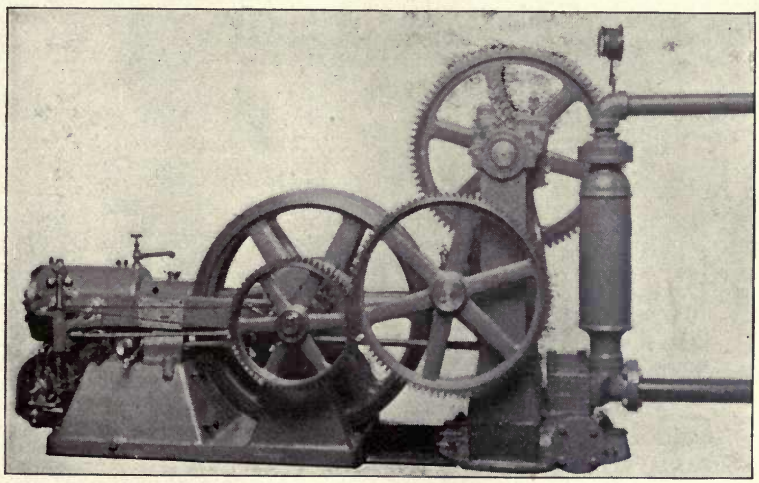


FIG. 30.—PRIESTMAN ENGINE AND PUMP COMBINED.

The Kane Electro-Vapor engine, like the one just described, is also adapted to the use of either gas or gasoline. It is built by Messrs. Thomas Kane & Co., Chicago, Ill., and is shown in Fig. 31 as ar-

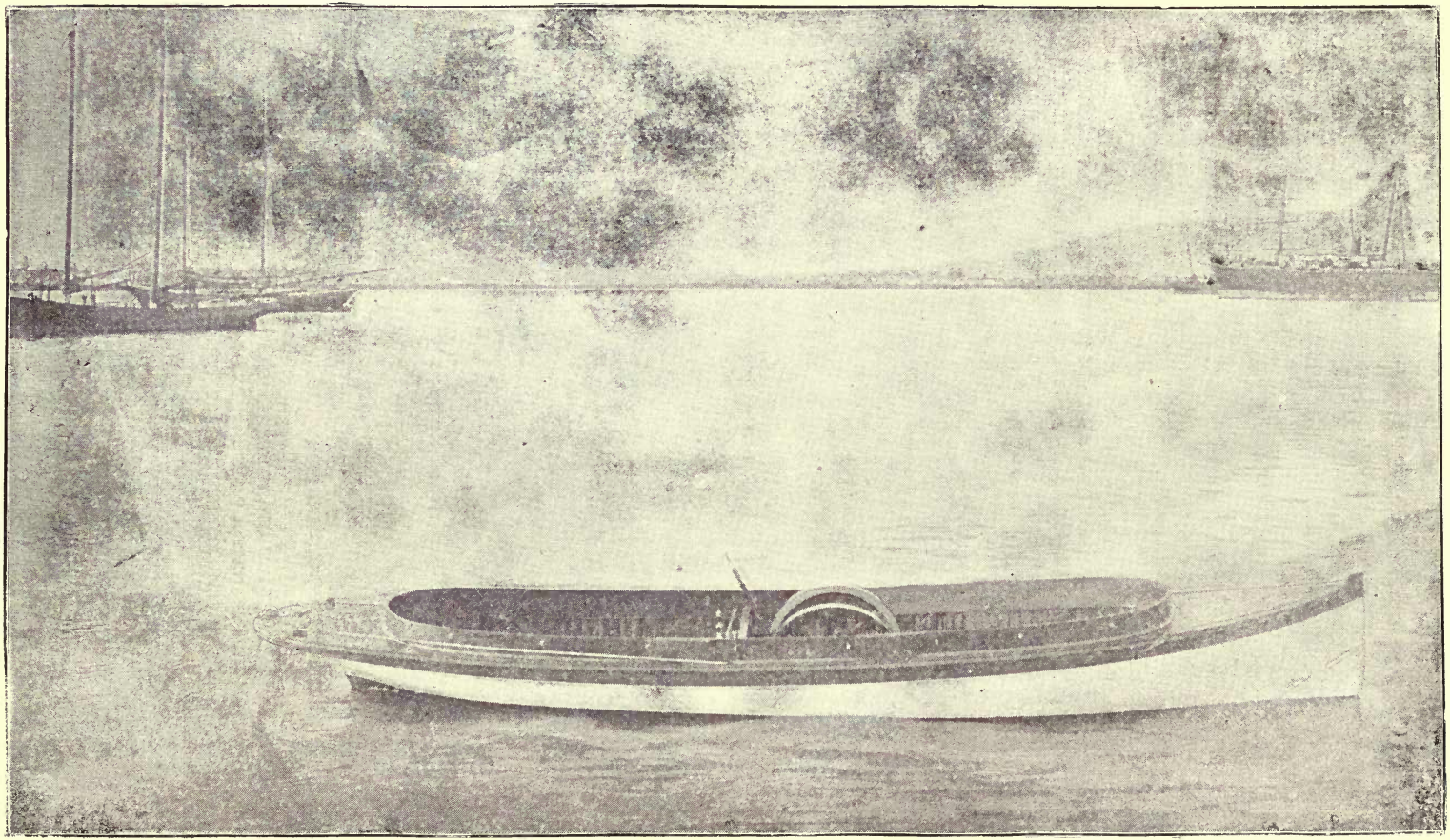


FIG. 33.—KANE ELECTRO-VAPOR LAUNCH.

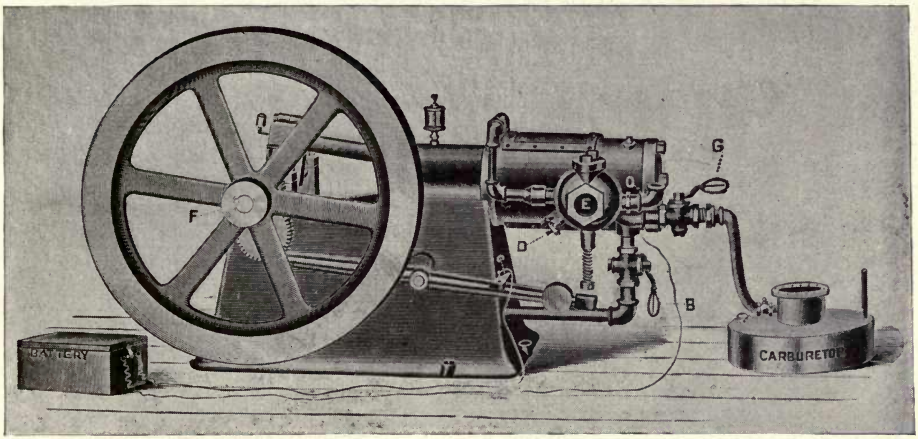


FIG. 31.—THE KANE ELECTRO-VAPOR ENGINE. BUILT BY THOS. KANE & CO., CHICAGO, ILL.

ranged for the use of gasoline. The engine works on the Otto cycle, there being one working stroke in every four. The gas or gasoline vapor goes to the engine through the regulating valve *G*, and mixes with a suitable supply of air, which is drawn in from the hollow bed of the engine through the cock *B*. The admission valve through which the mixture finally enters the exploding chamber is a poppet valve, operated by a lever on the other side of the engine, not visible in the illustration, and controlled by a centrifugal governor through a hit-and-miss device. Having passed through this admission valve during the first stroke of the cycle, the mixture is compressed during the second stroke, and exploded at the beginning of the third stroke, exhaust of the burnt gases, as usual in this class of engines, taking place during the fourth stroke. The exhaust valve chamber is marked *E*, the valve itself also being a poppet valve ordinarily kept closed by the spring shown. It is opened at the proper exhaust moment, however, by being pushed upward by the end of a pivoted lever, which receives motion from the crank shaft *F* through the intervention of a small and a large gear wheel, in much the same manner as that followed in connection with the Caldwell-Charter engine described in the beginning of this paper. The explosive charge is ignited by an electric spark, and one of the electric contact points, connected with one pole of a battery, is carried by the exhaust valve operating lever just mentioned. It is shown at *C* and is pressed against another contact piece on the engine bed at the end of every down stroke of the right hand end of this valve lever. The other pole of the battery is connected by a wire with an insulated electrode in the exploding chamber at the end of the engine cylinder. The second electrode is in the shape of a metallic point carried by the piston. At the proper

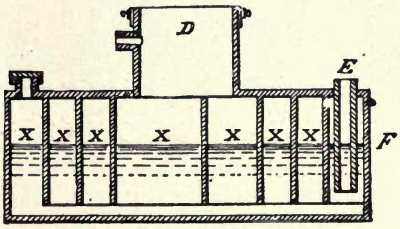


FIG. 32.—SECTION OF CARBURETOR FOR GASOLINE USE.

moment for exploding a charge, the contact pieces at *C* are pressing against each other, and the electrode on the piston, which then is at the right hand end of its stroke, is just breaking contact with the insulated electrode in the

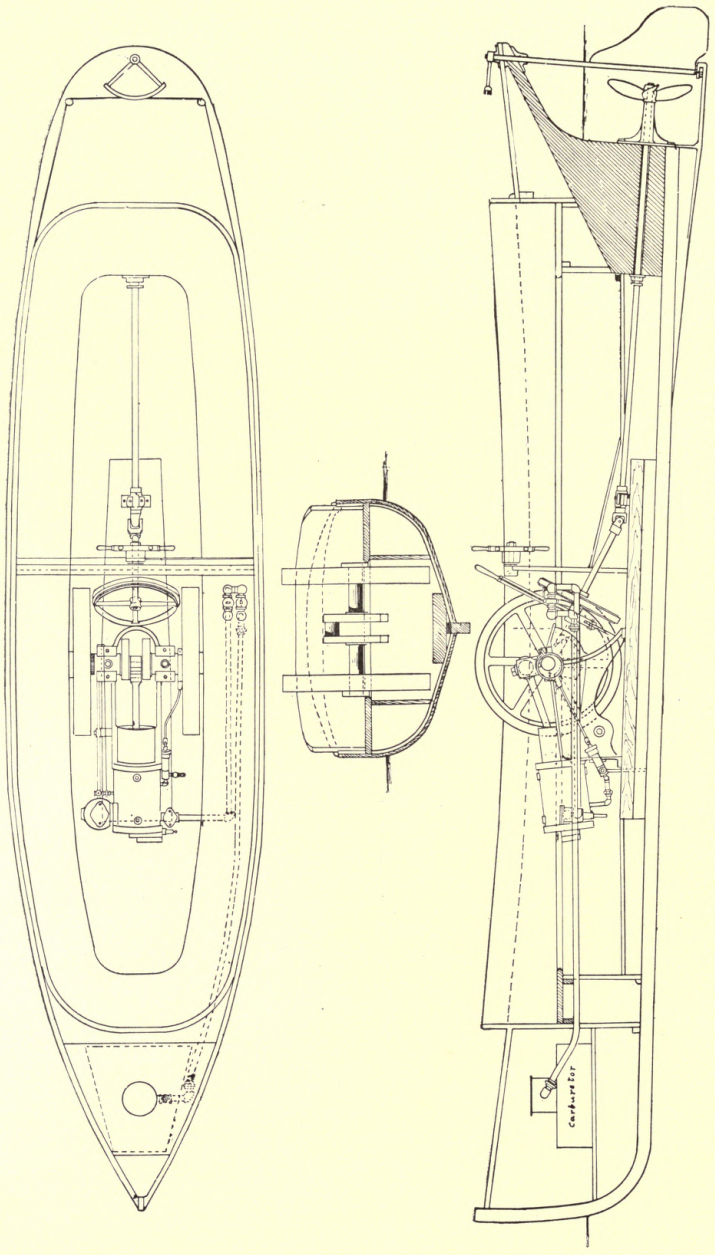


FIG. 34.—PLAN AND SECTIONS OF LAUNCH FITTED WITH KANE ELECTRO-VAPOR ENGINE.

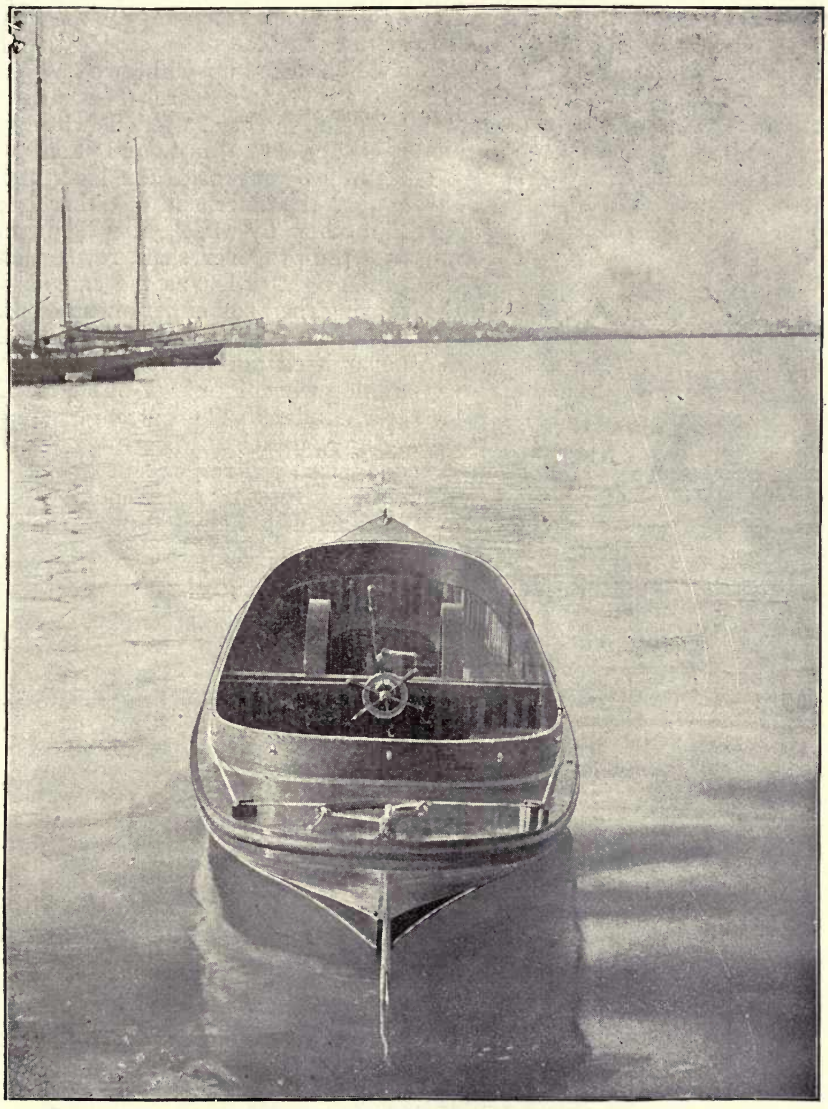


FIG. 35.—KANE ELECTRO-VAPOR LAUNCH.

exploding chamber. The result is that a spark is produced, and the charge is exploded. The contact pieces at *C* are for the purpose of completing the electric circuit only at the end of every fourth stroke. At other times they are separated as will be understood from the nature of the connection to the exhaust valve lever. The cylinder is water-jacketted, and the water on its way from the jacket passes around the exhaust valve chamber, cooling it also, and is led off through the pipe *O*.

Fig. 32 represents a sectional view of the carburetor or gasoline tank used when the engine is working with gasoline. It is a small circular tank partly filled with gasoline and connected with the engine by a pipe. It may stand five feet, or, for that matter, fifty feet away from the engine. Upon starting the engine, a current of cool air is drawn

through suction pipe *E*, and passing around through the circular chamber *X X X*, finally arrives at the gas box *D*; from there it passes directly into the engine cylinder through the connecting pipe. During its passage through the carburetor, the air absorbs the requisite amount of vapor for the charge. The carburetor works automatically and requires no attention other than that necessary to keep it supplied with gasoline. When the engine works with gas, the carburetor, of course, is not needed, and the end of the gas intake pipe carrying the valve *G* is then connected directly with a gas supply pipe carrying the customary gas-bag to give uniformity of pressure. The engine is made in seven sizes ranging from one-half actual horse-power up to ten. One of the uses to which this engine when using gasoline is being extensively applied is the propulsion of small boats, and special modifications have, accordingly, been made by the builders to successfully meet the requirements in such cases. Thus Fig. 35 gives a general view of one of the marine engine outfits. The engine, as there used, is fitted up with two fly-wheels and a reversing gear. The latter consists simply of a friction wheel with rubber rim so arranged that when thrown, by means of the lever shown, against the inner side of either one or the other fly-wheel, it will, together with the propeller shaft, revolve either to the right or left as the case may be, moving the boat either ahead or astern while the engine runs always one way, being itself not reversible. With the friction wheel in mid-position, it will be at a standstill. This arrangement provides a noiseless reversing gear and one which will respond at a moment's notice. Fig. 34 represents a plan and sections of a launch fitted up with the engine, while Figs. 33 and 35 are general views.

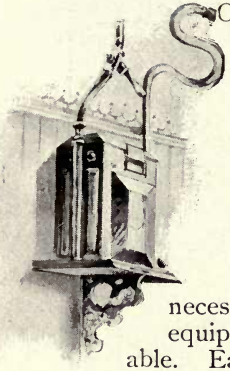
Messrs. Kane & Co. build also a vertical gas engine, and a special horizontal gas engine and pump combination designed for supplying water for hotels, residences, etc.

(*To be continued.*)

MODERN GAS AND OIL ENGINES.

By Albert Spies, Mem. Am. Soc. Mech. Eng.

Third Paper.



SOME uses to which gas engines are especially adapted have been mentioned in a previous article; one of these is the driving of electric light machinery, especially the dynamos of isolated lighting plants, where steam engines with the necessarily attendant boiler equipment are often undesirable. Ease of management and simplicity of power installation in such plants are frequently of the utmost importance and, coupled with the intermittent character of the service required, make the gas engine a prime mover of special acceptability. One of the several later types of gas engine which appear to have found much favor for such electric light service is the White & Middleton engine, built by the White & Middleton Gas Engine Company of Baltimore, Md., and illustrated in Figs. 36 and 37, the latter representing a sectional plan. This engine is of the prevailing two-cycle or so-called Otto type, to which repeated reference has already been made in connection with many of the engines described in the previous articles.

The piston is of the trunk pattern and is connected to the crank direct by the wrist-pin and connecting rod without an intervening cross-head. The gas and air are mixed in the chamber *a*, and the mixture is drawn through the valve *b* into the engine cylinder during the out-stroke of the piston. During the return stroke the mixture is compressed to about one-fourth its original volume, and, at the beginning of the second out-stroke, it is ignited by uncovering the inlet to an ignition tube. The ignition, or explosion, of the charge drives the piston forward. At the end of this working stroke, as it may be called, the piston uncovers the exhaust port *f* and the larger part of the products of combustion escapes. The portion still remaining in the cylinder, except that filling the compression or combustion chamber on the left-hand end, is expelled, during the following return stroke, through the valves *c* and *d*. This completes one working cycle, and the engine is then ready to take in a new charge of gas and air and go through the same series of operations.

The valves, it will be noticed, are all of the poppet type. The valve *c* is worked by the lever *g* pivoted at *h*. This lever receives its motion from the rod *i* and the latter, in turn, is operated by the slide *k*. A cam is placed on the crank-shaft at *l* and works with a smaller cam which imparts motion to *k*. This smaller cam is under the control of a centrifugal governor and a spring, being thrown out of gear with the larger cam whenever the speed of the engine exceeds the normal rate, and thus failing to open the admission valve *c* and the gas supply valve until the engine has again come down to its proper speed. Ordinarily, when the engine runs under a full load, these valves, of course, open at every other stroke. The valve *c* always opens slightly in advance of the gas supply valve, the latter being arranged in the casing shown at the side of the cylinder in the perspective view, Fig 1. In Fig. 2 it is not shown. A small valve is fitted to the opening *n*, and is opened and closed by hand for the purpose of relieving the air pressure in the cylinder on starting

the engine. It will be observed that, unlike many other gas engines, the one here shown has no gear wheel combination for reducing the speed for the valve gear, the necessary reduction being effected by an ingenious arrangement in the slide *k*. The governor also is quite to be employed, however, the gas supply valve on the side of the cylinder is replaced by a small pump worked also by the rod *i*. No outside carburetor is employed, but the pump discharges at every other stroke of the engine piston, or less frequently as de-

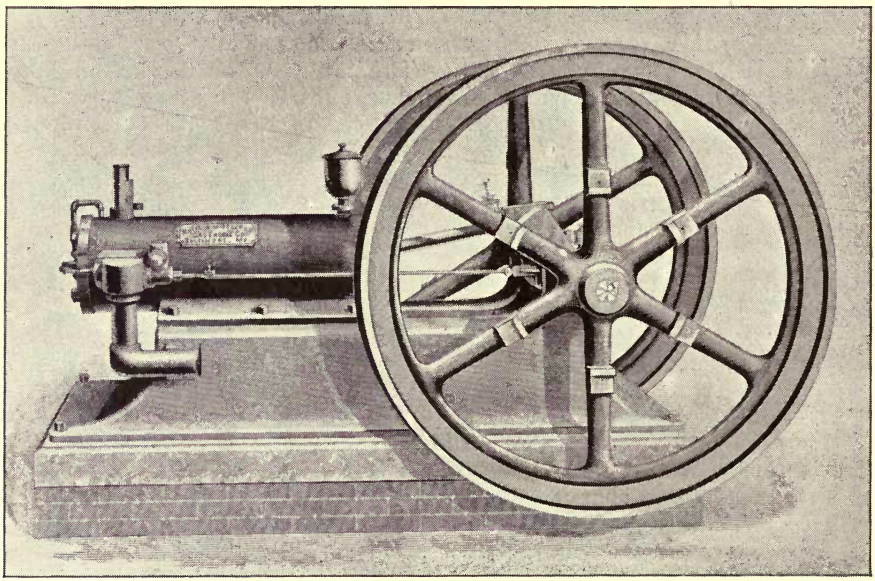


FIG. 36.—ENGINE BUILT BY THE WHITE & MIDDLETON GAS ENGINE CO., BALTIMORE, MD.

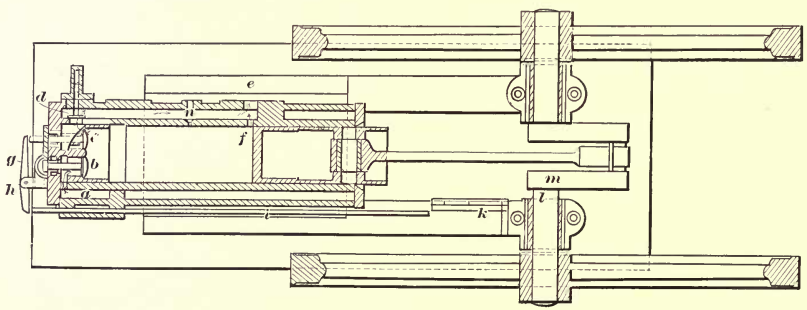


FIG. 37.—SECTIONAL PLAN OF WHITE & MIDDLETON ENGINE.

inconspicuous, and the whole engine is very simple in appearance, the number of working parts having been reduced to a minimum.

The engine, like many of those already described, is adapted to use gasoline as well as gas. Where gasoline is termined by the position of the governor, a suitable proportion of gasoline into the chamber *a* where it is taken up and carried along by the air into the cylinder through the self-acting valve *b*. The engine is built in sizes of from two to thirty-two indicated horse-power,

though arrangements are being completed to turn out larger sizes for which demands have been made.

The gas consumption of the engine is said to be remarkably small, test figures being claimed to have shown a consumption of nineteen cubic feet per brake horse-power per hour, in an engine developing actually 5.98, or in round numbers, six horse-power.

The combustion or power chamber is formed partly in a separate hood, as shown in the vertical section Fig. 39, and communicates at one side of the latter with the supply valve port. The forward end of the power cylinder opens into the crank casing which forms a compression supply chamber, the piston being the compressor. In this chamber work the connecting rod and crank,

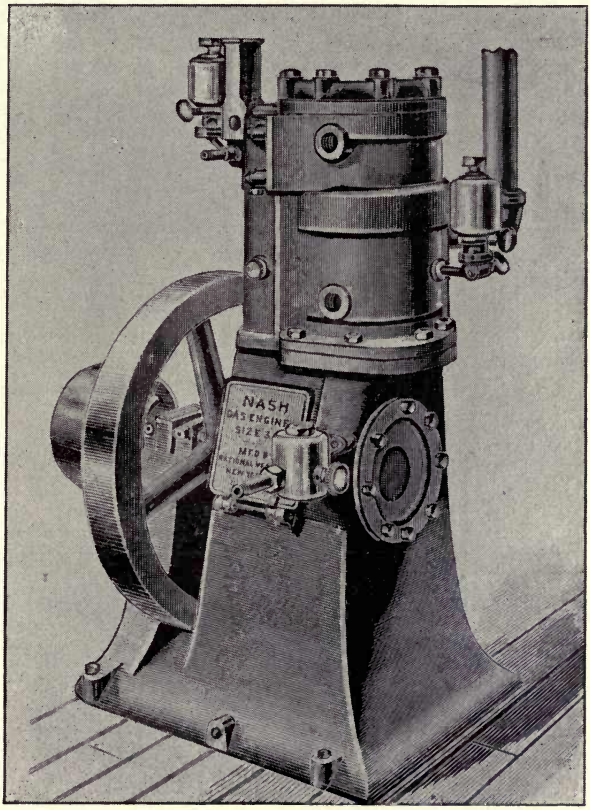


FIG. 38.—THE NASH ENGINE, BUILT BY THE NATIONAL METER CO., NEW YORK.

Another one of the later designs of American gas engines, known as the Nash engine, and built by the National Meter Company, New York city, is shown in perspective in Fig. 38. In this engine there is one explosion of a gas and air charge at every revolution instead of at every second revolution, and the engine is thus practically single-acting.

and into it the combustible mixture of gas and air is drawn during the upward stroke of the piston through the mixing valve, shown in Fig. 40, which is placed externally as represented in Fig. 41. This valve automatically regulates the relative supply of gas and air to the cylinder. Air enters through the opening at the bottom, while the flow of gas is regulated by the valve *f*.

In the interior are two valve ports of unequal area controlled by the double-seated valve *i* which regulates the flow of gas through the smaller port, and the flow of air through the larger one. It is evident that the relative quantities of air and gas drawn in by the upward movement of the piston will be in accordance with the size of the air and gas openings. The valve *i* is made of the piston is controlled by a poppet valve having an ample seat. The quantity of mixture admitted at each stroke is controlled by the valve *k*, operated by the governor. After ignition and expansion, the products of combustion escape through the circumferentially arranged exhaust openings in the cylinder walls, which are shown in both the sectional views and which are

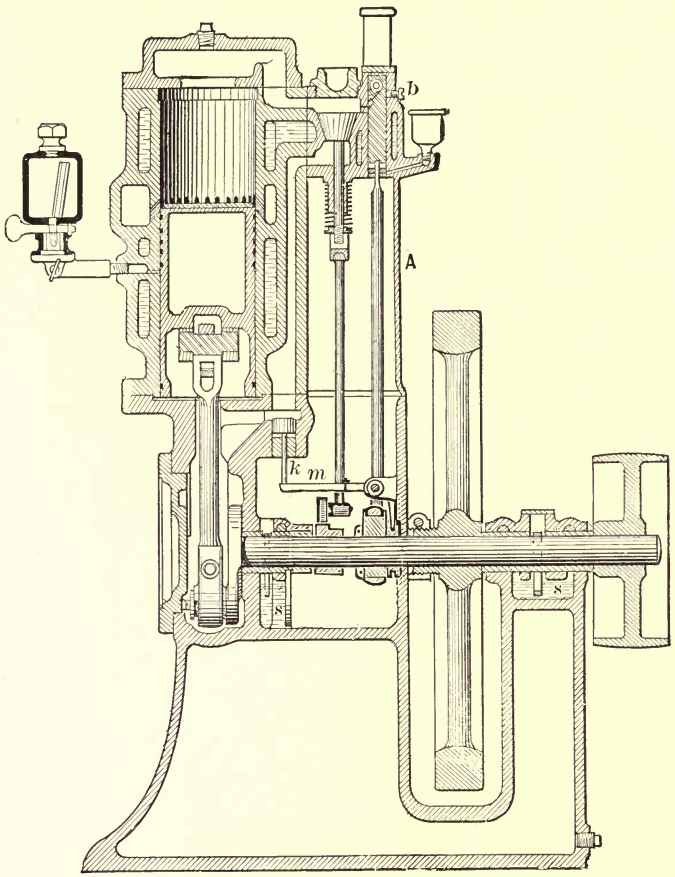


FIG. 39.—VERTICAL SECTION OF NASH ENGINE.

sufficient weight to greatly overbalance the gas pressure so that any slight variations in the latter will not materially effect the proportions of the parts of the mixture.

From the supply reservoir the mixture passes upward through a passage clearly shown in Fig. 39. Its admission to the combustion chamber above uncovered by the piston at the end of its down-stroke.

The igniter *b*, Fig. 39, and shown enlarged in Fig. 42, is based upon a new principle. The igniting jet of combustible mixture is caused to rotate in the circular chamber *r*, into which it enters through a passage tangentially placed. This forms a vortex of flame, which is

positive in its action and simple. The valve B itself is made of steel, and is hardened and ground to size. It moves in a reamed hole in the case, being so loosely fitted as to drop of its own

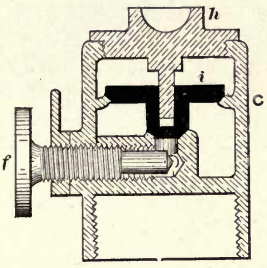


FIG. 40.—NASH MIXING VALVE.

weight, and yet making a gas-tight joint. Since the valve is pefectly balanced as to gas pressure it moves without friction, and therefore requires a very small quantity of oil—just sufficient to prevent it becoming dry. The valve is made long, and the lower part has a bearing in that part of the case kept cool by a water jacket. As oil is only applied to the lower end, very little can work up to the hot end where the igniter is heated ; hence the formation of gummy oil is prevented, and the valve seldom needs cleaning. In actual use it has been found that the case and upper end of the valve never come into metallic contact, as, on account of the looseness of fit at that point, a scale of hard carbon is formed over the surface of each, which protects them from abrasion. The valve is positively operated by an eccentric on the shaft.

As already stated, the engine ignites each charge at each revolution, and the amount of the charge is controlled at each stroke by the governor, so that the regulation is as close as for a steam engine. An examination of a card taken from this engine shows a remarkable resemblance to the card of a steam engine. The pressure at the beginning of the stroke is moderate, and the line of the expansion is well sustained throughout the entire stroke. The flywheel is stationed between two bearings formed in the single base casting ; hence the alignment of the shaft is always true. The working parts are enclosed and protected from dust, and at the same time they are readily accessible by hinged covers.

The engine is made in sizes of from one-third actual horse-power up to four horse-power, and, like all others of its class, is adapted to a wide variety of work. A special engine and pump combination, put on the market by the makers, has met with much favor and is widely used. Gasoline can be used with the engine as well as gas, but in that case, of course, some kind of carburetting device must be employed which forms an independent adjunct.

The Backus engine, made by the Backus Water Mfg. Company, of Newark, N. J., is shown in Figs. 43 and

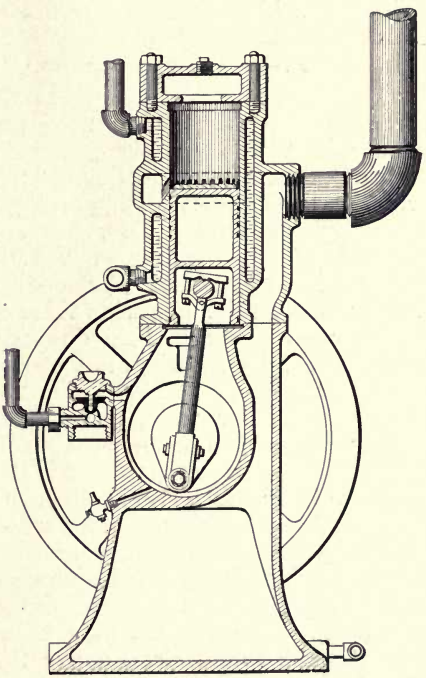


FIG. 41.—VERTICAL SECTION OF NASH ENGINE.

44. It is a vertical engine, made for small powers, and, like several already described, works according to the Otto cycle, there being one explosion in every two revolutions. Fig. 44, which

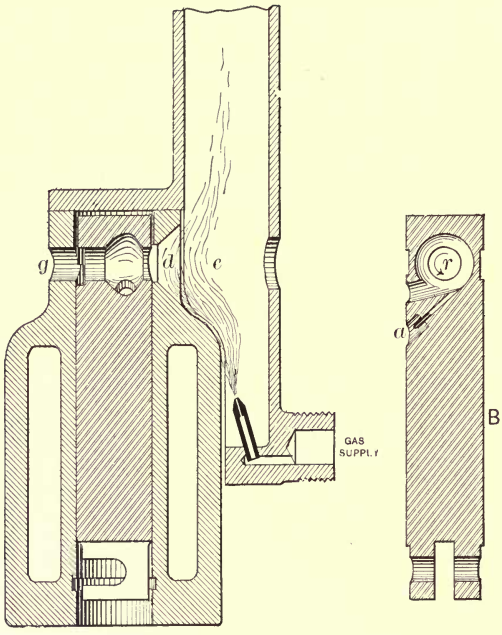


FIG. 42.—IGNITER OF NASH ENGINE.

represents a vertical section of the cylinder and valve mechanism, will help to clearly explain the functions of the several parts. The gas, coming through a special gas regulating valve, shown at the left in Fig. 43, enters at *a*, and, mixing with air, enters the engine cylinder through the admission valve *b*. This valve is ordinarily held down on its seat by a helical spring, not shown in the illustration, but lifts during the upward suction stroke of the piston, opening communication between *a* and the cylinder. Above the valve *b* is the exhaust valve *d*, which also is held to its seat by a helical spring, except when opened by the action of the exhaust valve rod which is operated by a gear wheel running at half the speed of the crank shaft. The exhaust pipe is indicated by the dotted circle above the valve *d*.

When the piston makes its first upstroke, the valve *b* opens and the explosive charge is drawn into the cylinder, the exhaust valve *d* being closed. On the following down-stroke compression takes place, both valves *b* and *d* being closed. At the end of this stroke the charge is in such a state of compression that it becomes ignited through that portion of it which has entered the incandescent ignition tube *c*. The piston is then forced up, doing useful work, and during the next down-stroke or exhaust stroke, the valve *d* is open and the waste gases escape. The engine, after this, is again ready to recommence the same cycle.

The governor, which is of the centrifugal type, is arranged in the belt pulley shown at the upper left-hand corner of Fig. 43. As the revolving weights of the governor move outward under the influence of centrifugal force they move the upper end of a centrally pivoted lever, shown in the perspective view. The lower end of this lever is attached to the gas valve, which is thus opened or closed more or less, depending upon the engine speed and the corresponding position of the governor weights. At the lower end of the lever there is also a knurled collar, by turning which the connection between

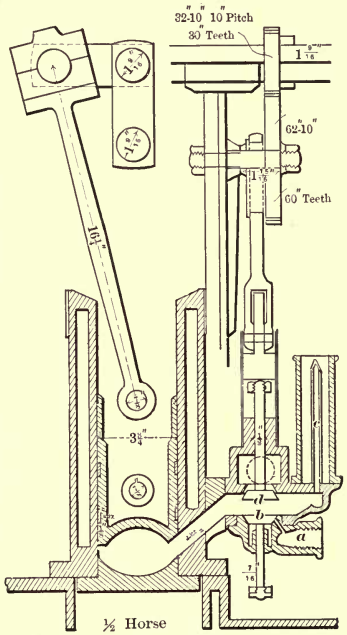


FIG 44.—VERTICAL SECTION OF THE BACKUS ENGINE.

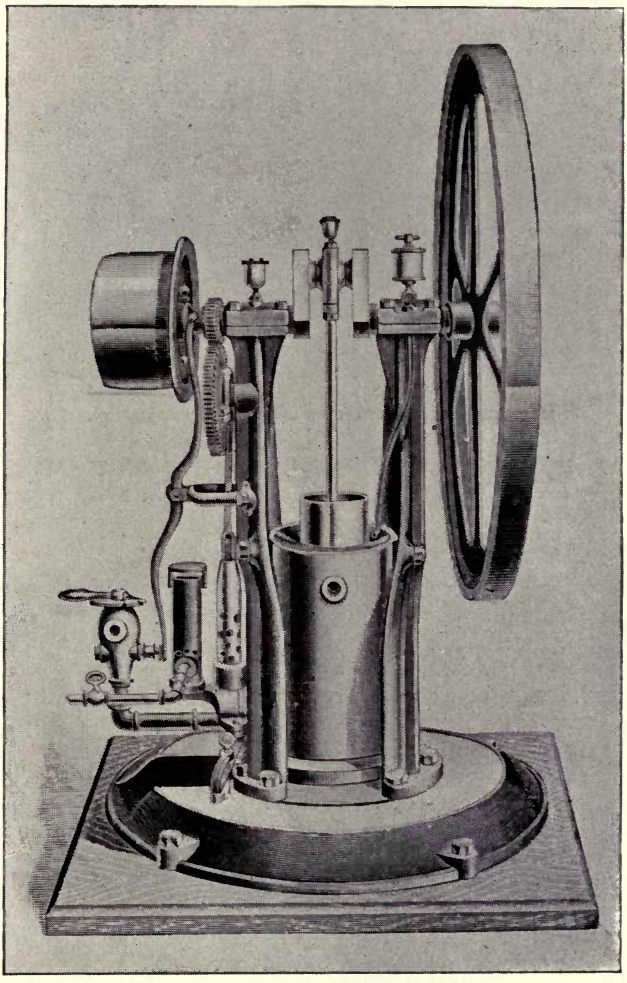


FIG. 43.—THE BACKUS ENGINE, BUILT BY THE BACKUS MANUFACTURING CO., NEWARK, N. J.

the lever and valve can be either shortened or lengthened, and the speed of the engine can thus be changed while the engine is in motion. The engine cylinder is provided with the customary water jacket to prevent overheating. The sizes of the engine range from one-half to three horse-power.

(*To be continued.*)

MACHINERY HALL, WORLD'S COLUMBIAN EXPOSITION.

STEAM ENGINES AT THE WORLD'S FAIR.—I.

By Geo. L. Clark.

OF all the great structures at the World's Columbian Exposition at Chicago, the Administration Building, while not the largest, is one of the most beautiful, if not the gem of the Exposition palaces. Machinery Hall, however, has been pronounced second only to this in the magnificence of its appearance. It measures 846 by 492 feet, and, with the Machinery Annex and Power House, cost about $1,250,000. These several structures together cover an area of nearly eighteen acres. The main machinery hall is spanned by three arched trusses, and the interior presents much of the appearance of three great railroad train houses. In each of the long naves is an elevated traveling crane, running from end to end of the building for the purpose of moving machinery. During the time of the Exposition it is intended to put platforms on these, so that visitors may be carried throughout the exhibition space and view all the machinery.

That with such extensive provisions for the exhibit of machinery the latter will form a most important feature of the Exposition seems almost needless to say, and that steam engines will be of the first prominence in this line of exhibits will be equally well appreciated. Interest will undoubtedly be centred in the large Corliss engine, one of magnificent proportions, built by the E. P. Allis Company, of Milwaukee, Wis., and suggestive at once of comparison with the famed Corliss engine used in Machinery Hall at the Philadelphia Centennial Exhibition in 1876, which was built by George H. Corliss. The illustration of that engine, shown on another page, will give the reader some idea of the great dissimilarity of the two. This Corliss engine, at the time one of the finest examples of its type ever constructed, had a pair of forty-inch cylinders, of ten-foot stroke, and while its full power was never developed, it supplied something like 1250 horse-power while in operation at the Exhibition. The length of the beams, between centres, was twenty-five feet, the diameter of the crank shaft was nineteen inches, and the diameter of the fly-wheel was nearly thirty feet. The revolutions of the Centennial engine per minute amounted to thirty-six, and it may be of interest to know that the total number of revolutions made during the exhibition was 2,355,300.

The duty of the World's Fair engine will, however, be of a different nature from that of the Corliss engine at the Centennial, which transmitted its power

cent. of the through passengers from New York to Chicago, although in elegance and comfort there is little choice between its limited trains and those of the Pennsylvania. Were it not, however, for the passengers who stop off at intermediate stations, these through fast express trains would be very unprofitable ventures.

From official reports it is found that the average number of through passengers on all trains to Chicago, both fast and slow, is one hundred and seventy daily. Divided up between the twenty-six through westbound trains it gives an average of eight each. Of the twenty-six through trains, the New York Central runs eight. This new train, however, will undoubtedly carry as many through passengers as it can accommodate between the World's Fair city and New York.

Another remarkably fast train will be that of the New York, New Haven and Hartford Railroad, which will shortly be put on and which will make the run between New York and Boston in five hours. The train will run by way of Providence, and will be the fastest ever run in New England, the average speed being forty-eight and nine-tenths miles an hour, including three stops of five minutes each. Trains will leave New York and Boston simultaneously, at ten o'clock in the morning, and reach their destinations at three in the afternoon, making almost as good time as the "Exposition Flyer" just referred to. The train is scheduled to

Leave New York	at 10.00 A.M.		
" New Haven	" 11.35	" 73.23	miles.
" New London	" 12.43	" 124.20	"
" Providence	" 2.06 P.M.	188.20	"
Arrive Boston	" 3.00	" 232.20	"

West of Chicago probably, the fastest train is on the Chicago, Burlington and Quincy road, running between Denver and Chicago. Train No. 6, eastbound from Denver, makes the run in twenty-nine hours and forty-nine minutes, the distance being 1025 miles. Train No. 1, leaving Chicago daily for Denver, makes the run in thirty hours and fifteen minutes. The engines hauling these trains are of the eight-wheel American type, built by the Rogers Locomotive and Machine Works. They belong to the standard class "M" locomotives of the road, have eighteen by twenty-four-inch cylinders, sixty-nine-inch drivers, and weigh, with tender, ready for service, 174,000 pounds. The total weight on the drivers is 65,500 pounds.

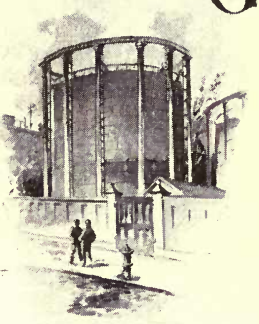
Reviewing all the facts presented, it appears that, notwithstanding the great variety in type of locomotives and weights of trains, the running time between various terminals both in England and America, whether the distance be long or short, does not much exceed fifty miles per hour. At the same time it has been demonstrated that a speed of sixty to sixty-five miles is made by many roads daily for part of a run, and as high as 80 to 100 miles for a short stretch on a particularly good piece of roadbed has been accomplished by different types of locomotives. The superiority of any particular type among those illustrated is hard to determine, although for many reasons the locomotives of the "800" class, hauling the Empire State Express on the New York Central road, are capable of pulling a train faster for a long distance than any now in use.

There is no doubt that as regards first-class express trains those in the United States lead in point of speed over long distances, exceeding, say 200 miles. For shorter runs, however, in the neighborhood of 100 miles, the English regular trains still hold the supremacy.

MODERN GAS AND OIL ENGINES.

By Albert Spies, Mem. Am. Soc. M. E.

Fourth Paper.



GAS at a low price, much lower than that at which it is now generally sold by gas companies, is one of the desiderata to which gas engine builders and users alike have been looking forward for some time. It is not that the gas engine, even with the current prices of gas, is by any means unduly expensive in point of fuel, but it is manifest that with cheaper gas the full possibilites of motors of this type would be more readily and widely appreciated, and could be more strikingly emphasized by the probably greatly increased numbers in use. In one of the preceding papers a few figures were given, showing what was actually accomplished with a cheap heating gas in the line of reducing the cost of power in a gas engine. Unfortunately, however, enterprises of the character there mentioned, keeping in view the manufacture and distribution for general consumption of low cost gas for heating purposes, have not yet been pushed to any extent, and users of the larger sizes of gas engines, developing about forty horse-power and more, who have been impressed with, and who decided to profit by, the economies of cheap gas utilization have been obliged to avail themselves of special gas producer outfits to be worked in conjunction with their engines, just as steam boilers ordinarily are operated in connection with steam engines.

This plan of putting in independent gas producers has been specially developed in England, and a comparatively large number of such gas plants on the Dowson system have been built and operated with the most satisfactory results. The outfits, as generally used, consist of a small gas holder and tank with a scrubber placed inside the tank. The scrubber is filled with coke or other suitable material, and the gas, as made, is passed through this before it reaches the holder. A regulator on the gas producer governs the production of gas, within certain limits, by the rise or fall of the holder, and makes large storage capacity unnecessary. In some of the outfits an escape valve has been used on top of the holder to let off gas into the open air or up through a waste pipe when the holder is full, and when the make of gas exceeds the consumption. This, however, has not been employed to any great extent, since the regulator arrangement satisfactorily provides for fluctuations in consumption and avoids the waste of fuel.

The gas is made by forcing a continuous current of steam and air through a coal fire in the producer proper, or generator, so that the necessary high temperature of the fire is maintained while a constant volume of steam is decomposed. The oxygen of the air and steam combines with the carbon, producing carbonic oxide which is rendered still more inflammable by the hydrogen set free by the steam. The total cost of the gas, including wages, etc., and allowing for the increased volume of the gas required to develop the same power as coal gas, has been found, it is stated, to be equal to coal gas at about forty cents per 1000 cubic feet. The result of this certainly very acceptable

price has been, as already intimated, the installation abroad of quite a large number of Dowson producers for private use, and the gradual adoption of gas engines of larger and larger sizes, so that now there remains very little cause for the impression, still entertained by some, that the gas engine is essentially a small power motor. In the United States, combination engine and producer plants are not so well known, or, at least, not so much used, but their advantages are pretty well appreciated, and their more extensive introduction would seem to be a matter of but a few years. Plants of this kind are already in use there in several places, and, from all accounts, seem to be doing satisfactory work. Where they are put in, one is, of course, entirely independent of gas companies, just as in the case of oil engines, the whole outfit being complete in itself.

Careful tests of Otto engines working in conjunction with Dowson producers, as already stated in one of the preceding papers, have shown a fuel consumption as low as 1.2 pounds of coal per indicated horse-power per hour, and Messrs. Crossley Brothers, of Manchester, the English builders of the Otto engine, in the early days of Dowson gas found that the wages of a fireman for several gas generators are not more than those for a set of steam boilers. The gas also can be conveyed with little loss from condensation to various parts of a large establishment using power, and independent gas engines can thus be employed for different lines of shafting. Any department working overtime can have its engine supplied with gas from a single generator, and all the advantages can in this way be secured that are usually claimed for, and achieved by, the system of sub-division of power.

To return, however, from this brief digression to the descriptions of currently used engines, we will present, to begin with, the so-called "Safety Vapor" engine, shown in Fig. 45, and put on the market by the Safety Vapor Engine Company, of New York. A feature at once noticeable in this engine, which also works on the Otto cycle, is the chain or link belt shown at the right, operating the valve. The latter is simply a flat, circular plate with one port cut through it in the shape, nearly, of a sector of a circle. The valve seat is provided with two similarly shaped ports placed close together, one for admission of the charge into the cylinder, and the other for exhaust.

Two ports, exactly the same in shape and similarly located, are provided in the cover plate which holds the valve in position. One of these ports communicates with the exhaust pipe and the other with the gas and air supply pipe. The valve, it will be understood, rotates constantly in one direction and as the port in the valve establishes communication between the first seat port and the corresponding port in the cover plate, exhaust takes place. The valve, proceeding further around, next brings its port over the adjoining admission ports in the seat and cover plate, and the charge of gas and air then enters the cylinder, and is subsequently compressed, ignited, and expanded while the valve completes its revolution until its port again establishes communication between the exhaust ports. This completes one cycle. The valve, of course, makes only one revolution for every two revolutions of the crank-shaft, the large link belt pulley above having twice the diameter of the smaller pulley below which drives it.

The gas goes to the engine through the horizontal branch pipe, shown at the left in the illustration, passes through a graduating gas valve by which the gas supply, and consequently the speed of the engine, can be regulated, and then mixes in a pipe chamber with air taken in through the vertical pipe shown extending downward. The mixture finally enters the admission compartment of the valve chest. Ignition of the charge is effected electrically by a spark passing between two electrodes in the extreme upper end of the cylinder, the current being furnished by an electric battery. Special electric

contact strips are arranged on the valve chest cover and are brought together once in every revolution of the large link belt pulley operating the valve. By this arrangement a spark between the electrodes in the cylinder is produced once in every two revolutions of the crankshaft, or at the beginning of every fourth stroke of the piston.

The engine, as shown in the illustration, is arranged for use in a launch and for this purpose is fitted up with a friction driving gear for the propeller shaft. This gear is similar to the one already described in connection with the Kane electro-vapor launch engine in the April number, and its action will be at once understood from the illustration. There are, as will be observed, two friction wheels, mounted in a frame pivoted on the propeller shaft. The latter carries a third and larger friction wheel, which is in contact with the other two. By means of a lever extending upward, the frame with its two friction wheels, may be thrown over to either one side or the other, bringing the wheels into contact with the rim of either one of the engine fly-wheels and thus causing the propeller shaft to revolve in either direction as desired, driving the launch either ahead or astern. When the friction gear lever is in mid-position, both of the small friction wheels are out of gear, and the engine revolves idly, the propeller shaft being at rest. The stationary engine is exactly similar to the marine engine, except that it is provided with a governor belted to the engine shaft and controlling the main gas valve, either reducing the amount of gas admitted or cutting off the supply altogether when the speed of the engine rises above the normal. The engine is built in sizes of from one-half to six horse-power and, as may have been already gathered from the fact that it can be applied to boat propulsion, is adapted to the use of gasoline as well as gas.

The Rollason gas engine, of which both horizontal and vertical designs are shown in Figs. 46 and 47, is the invention of Arthur Rollason, and has been in use in England for several years with very satisfactory results, the English builders being Messrs. Wells Brothers, of Sandiacre, near Nottingham. It is now also being made in the United States by the Electric

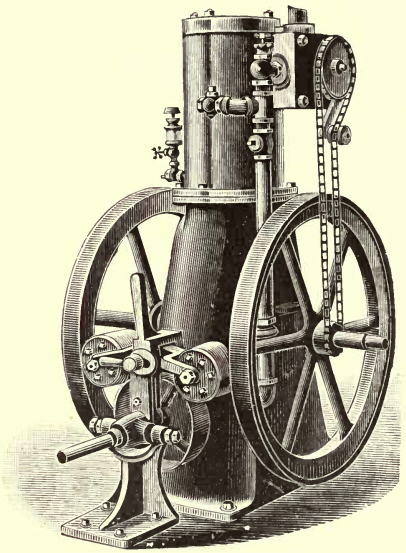


FIG. 45.—THE SAFETY VAPOR ENGINE.

Manufacturing and Gas Engine Company, of Greenbush, N. Y.

When first brought out, the engine was of the three-cycle type, that is to say, there was in ordinary working, one explosion or impulse in every three revolutions or in every six strokes. An explosion having taken place, the piston made a forward stroke under its impulse ; then the exhaust valve was opened, and the piston on its return expelled a large proportion of the products of combustion. During the second forward stroke the piston drew in behind it what was termed a scavenger charge of air which it forced out on the back stroke together with what remained of the burnt gases. On the third outward stroke a combustible charge of gas and air was drawn in, and on the next back stroke, or sixth stroke, this mixture was compressed ready for ignition. This completed the

cycle, and the engine was then ready to again go through the same series of operations. In the engine as now built, however, a four-stroke cycle is followed, and yet the use of the scavenger charge is retained, a feature which is probably not found in any other four-stroke cycle gas or oil engine now on the market. The particular advantage of a scavenger charge of air will be appreciated when it is borne in mind that ordinarily the clearance spaces in a gas engine cylinder are filled with used-up gases when the fresh charge of explosive mixture enters the cylinder, and these remaining burnt gases probably exert a delaying action on the explosion.

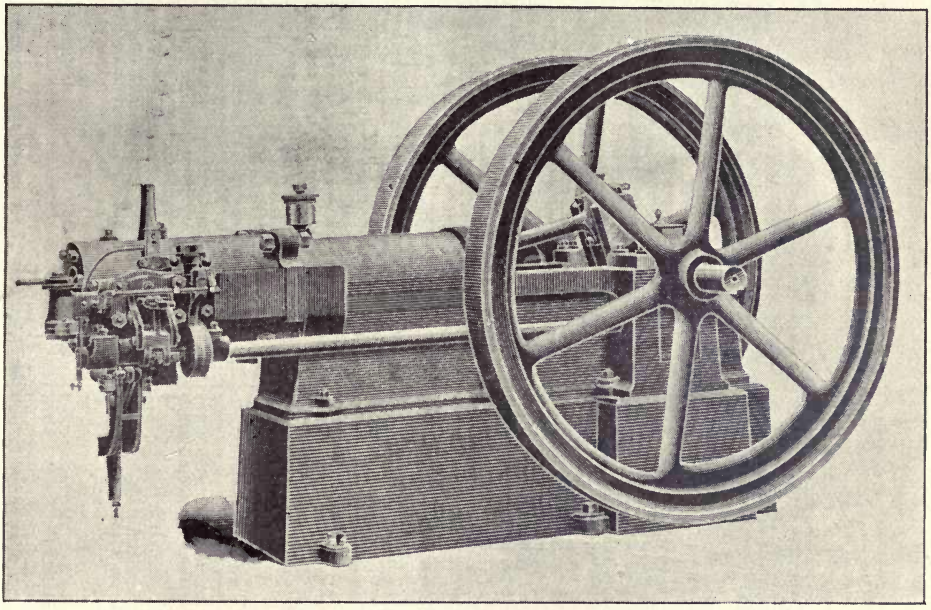


FIG 46.—THE ROLLASON HORIZONTAL GAS ENGINE.

The interior construction of a portion of the Rollason engine is shown in the sectional views Figs. 48 and 49, from which it will be seen that in front of the cylinder is a long tubular guide in which works a second piston rigidly connected to the front. This tubular guide and piston constitute a pump in which air, slightly compressed, forms the scavenger charge. Air enters through the valve F in the bed-plate, and gains access to the passage E, one end of which communicates with the pump and the other end with the air valve entering the main cylinder. On the suction stroke of the main piston, air is drawn into the pump, and a gas and air mixture into the cylinder. On the compression stroke the air is compressed in the pump, but only slightly, because the clearance space is so large. On the explosion stroke this air is expanded. As soon as this stroke is completed, the exhaust valve C opens, and the main piston, returning, sweeps the products of combustion before it, while the pump piston compresses the air. Shortly before the end of this stroke the air valve is opened and allows the compressed charge from the pump to rush into the cylinder and out through the still open exhaust valve. The exhaust valve is kept open until the crank passes the centre, affording ample time for all the products of combustion to be completely swept out. The annular gas valve is

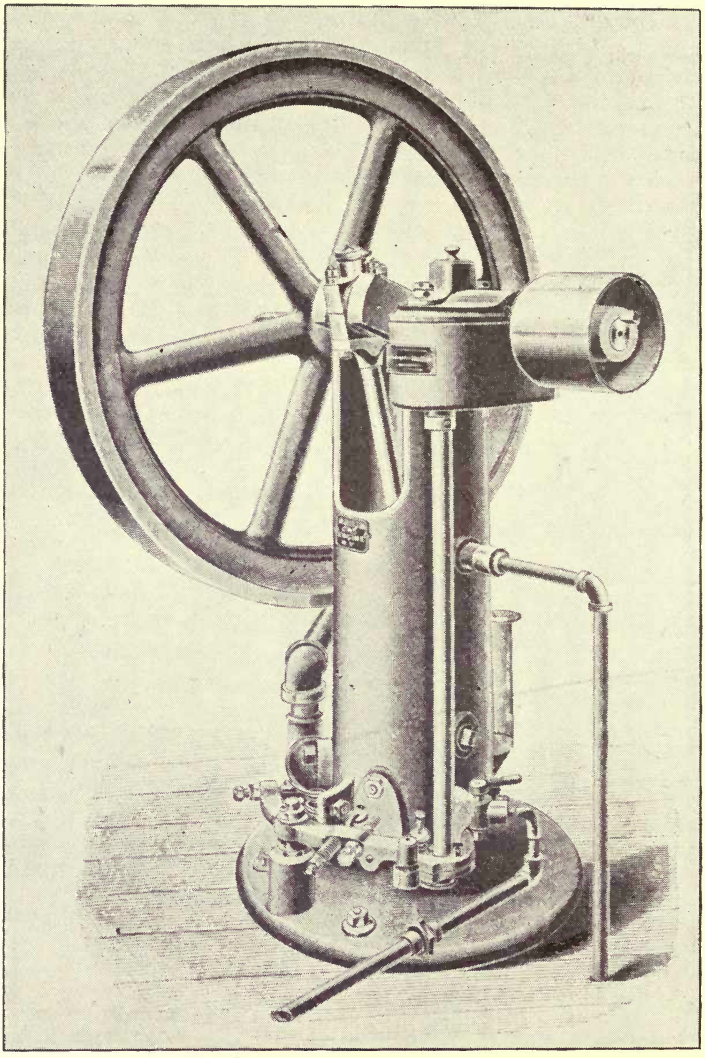


FIG. 47.—THE ROLLASON VERTICAL GAS ENGINE.

then opened and the motor piston draws in its charge.

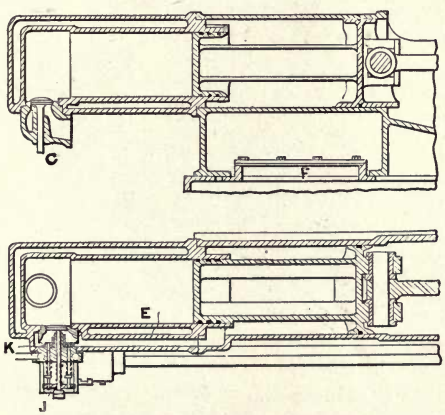
The regulation of speed in the large engines is effected in two different ways. There is a centrifugal governor connected with a throttle valve, and small variations of load are met by reducing the strength of the charge. If the speed is greatly increased, however, the gas valve is not opened at all. It is worked by a hit-and-miss device, and at high speeds a cam connected to the governor trips the device and cuts off the gas.

The admission and exhaust valves are of the poppet type, and the original slide-valve design has been abandoned as in most other makes of gas engine. Firing of the charge is effected by a tube igniter.

The nature of the valve gear will be made clear by an examination of Fig. 50, which represents a cross-section of

the cylinder and of the valve chambers. The explosion or combustion chamber A is surrounded with the usual water jacket and has the passage *a* through which air enters on its way to the air admission ports *b*. The lay-shaft B is driven from the crank shaft by reducing gearing and is provided with a cam, C, for operating the igniting device, and with a second cam, D, for governing the admission valve E and exhaust valve F through the intervention of a two-armed rocking lever pivoted at G. This lever carries at one end a roller, H, which is kept pressed against the cam D by means of the spring J. When the cam D forces the roller H outward, the opposite end of the rocking lever strikes the stem of the exhaust valve F and lifts this valve from its seat, at the same time enabling the admission valve E to close under the influence of the spring with which it is provided. Thus the movement of the lever in one direction under the action of the roller H opens the admission valve, and the return movement under the influence of the spring J opens the exhaust valve, the latter also being fitted with a spring, as shown.

The admission chamber, as already



FIGS. 48-49.—SECTIONAL VIEWS OF THE ROLLASON ENGINE.

stated, is provided with air ports *b* which communicate with the external air through the passages *a*. The gas chamber K, on the other hand, communicates with the source of gas supply and has small ports governed by a lift valve, *c*. Let us suppose now that an explosive charge of gas and air is being compressed in the cylinder end

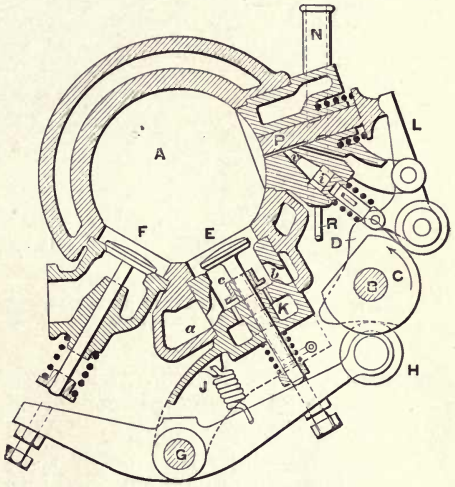


FIG. 50.—VALVE GEAR DETAIL OF ROLLASON ENGINE.

A. A small portion of the compressed charge will escape through a narrow groove into the port *v*, and pass from there through the port *i* into the chimney N, where it is ignited by the gas flame from R. The flame of the ignited mixture passes back into the port *v*, but the fineness of the groove *m* prevents it from passing into the cylinder end A. When the time of igniting the charge in the cylinder has arrived, the cam C permits a quick outward movement of the piston valve P, first closing the port *i* by a small valve controlling it, and afterward opening the small end of the port *v* by the completion of the out-stroke of the piston valve P. The flame is thus first shut in, and then put in free communication with the combustion chamber A, effecting ignition of the charge. The pressure in the combustion chamber, acting through the piston-valve P upon the three-armed rocking lever L, tends to keep the valve which controls the opening *i* tight upon its seat.

For starting large engines, the ar-

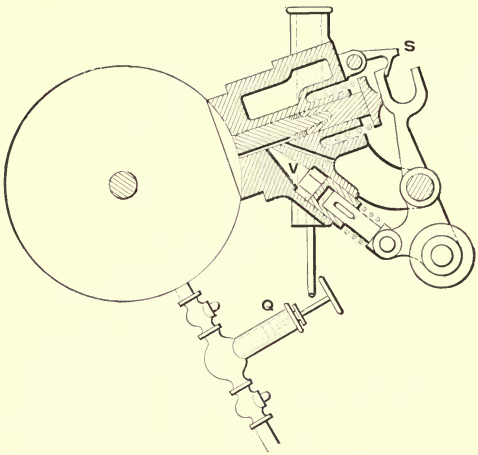


FIG. 51.—DETAIL OF STARTING GEAR FOR LARGE ROLLASON ENGINES.

rangement shown in Fig. 51 is used. A separate hand pump Q, is connected with the gas supply pipe, provided with check valves, so that a sufficient quantity of gas may be pumped into the combustion chamber to form an explosive mixture. To effect ignition of this mixture, the igniting device is provided with a releasable catch, S, Fig. 51, to hold it in the non-igniting position after the crank has turned the centre. If the mixture be burning in the passageway *v*, the release of the catch S will cause ignition and explosion of the contents of the engine cylinder.

In the smaller sizes of engine, the vertical engine, for example, the special igniting valve is not used, and the two-armed rocking lever controls simply the admission and exhaust valves, the tube igniter being always in direct communication with the end of the engine cylinder. The engine shown in Fig. 56 is one of two indicated horse-power. The horizontal design is turned out in sizes to meet the demand.

An example of what is being done in Germany in the way of petroleum engines is afforded by the Capitaine engine shown in elevation and vertical section in Figs. 54 and 55. This engine is now being introduced into England by Mr. L. Tolch, of Liverpool.

The engine works on the Otto cycle. Oil is taken through a pump at K, Fig. 54, and is forced into the vaporizer D, Fig. 55. This vaporizer is kept hot by a flame from the lamp C. The latter is provided with a long tube which bends back upon itself, and ends in a burner cone. The flame plays on the lamp tube as well as on the vaporizer, and in this way the pretroleum is converted into vapor before it reaches the burner cone. The ignition tube F also stands in the flame, and is made incandescent for the purpose of firing the charge, which is compressed within it on the second stroke of the piston. In the latest form of the engine, however, the use of the ignition tube has been abandoned, and the charge is fired by the heat of the vaporizer alone. On the first stroke of the piston air enters through the pipe B and inlet valve A, while the contents of the vaporizer are

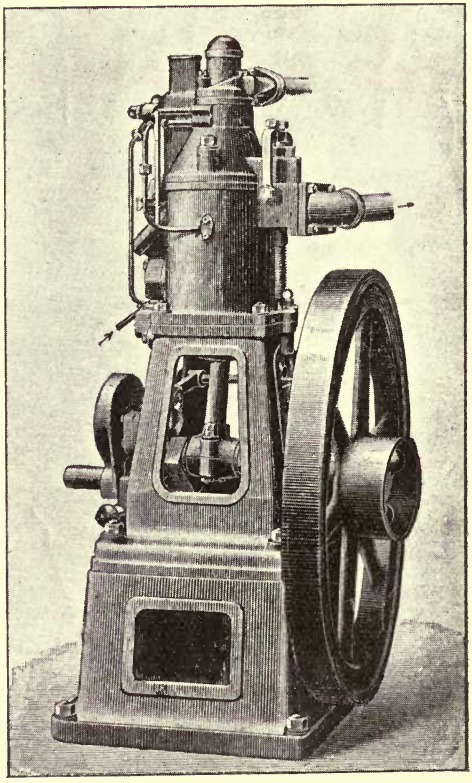


FIG. 52.—THE CAPITAINE OIL ENGINE.

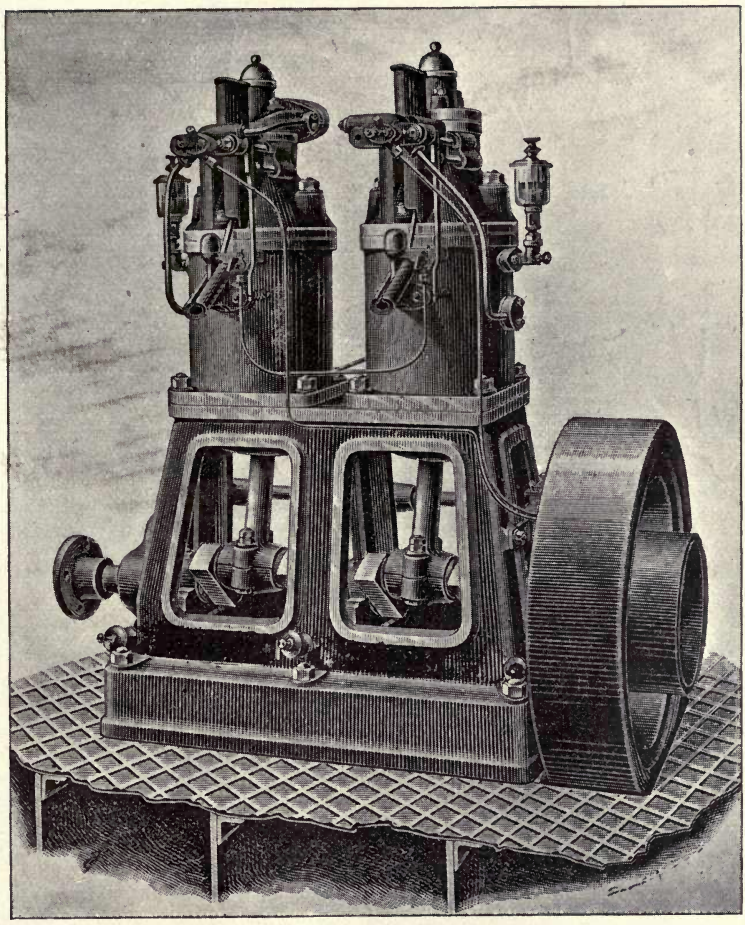


FIG 53.—DOUBLE-CYLINDER CAPITAINE LAUNCH ENGINE.

drawn out by admitting air at its end through the valve C.

The exhaust valve and the oil pump are both operated by an eccentric. As they are required to move only at each alternate revolution, the mechanism shown in Fig. 56 is introduced to throw the eccentric rod in and out of engagement. The eccentric rod is pivoted to a slipper working in a guide ; to this slipper is pivoted a cross-piece S with two arms. These arms work in conjunction with two fixed shoulder pieces striking them in succession. If with the parts in the position shown, the cross-piece were to rise it would operate the bell-crank M. As it neared the end of its travel one of the arms would strike the right-hand shoulder, tilting the cross-piece, so that on its next stroke it would miss the bell-crank. The left shoulder piece could then restore the cross-piece to its old position, and on the next stroke the bell-crank would be moved.

The bell-crank M works the lever L, one member of which raises the exhaust valve O, Fig. 55, while the other operates the pump, Figs. 54 and 57. The oil enters the tube at V by natural pressure, and through the small aperture at the bottom of the bucket S ascends up to the non-return valve H. On pressing the pump rod W upward,

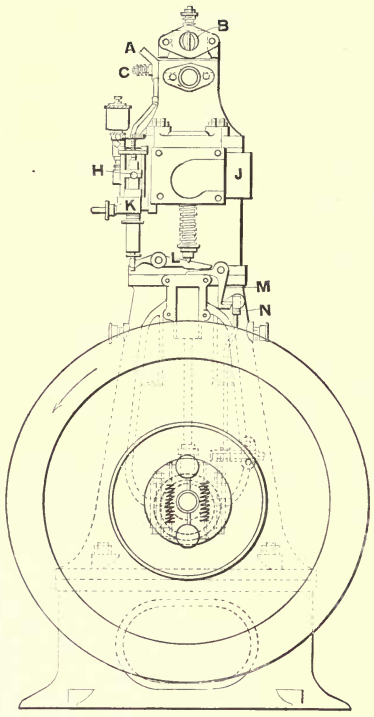


FIG. 54.—ELEVATION OF THE CAPITAINE ENGINE.

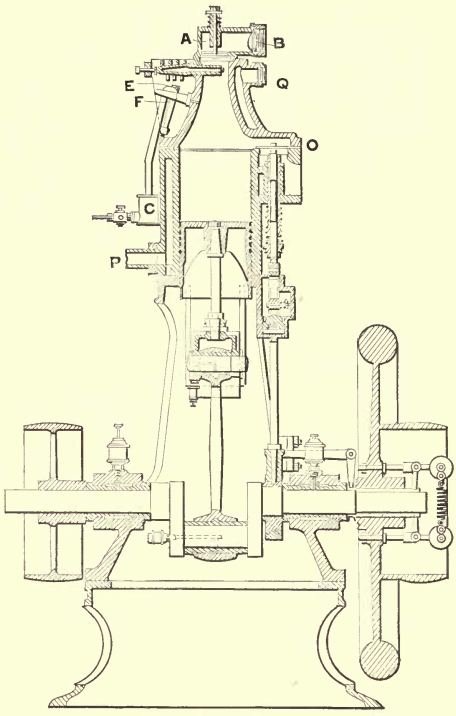


FIG. 55.—VERTICAL SECTION OF THE CAPITAINE ENGINE.

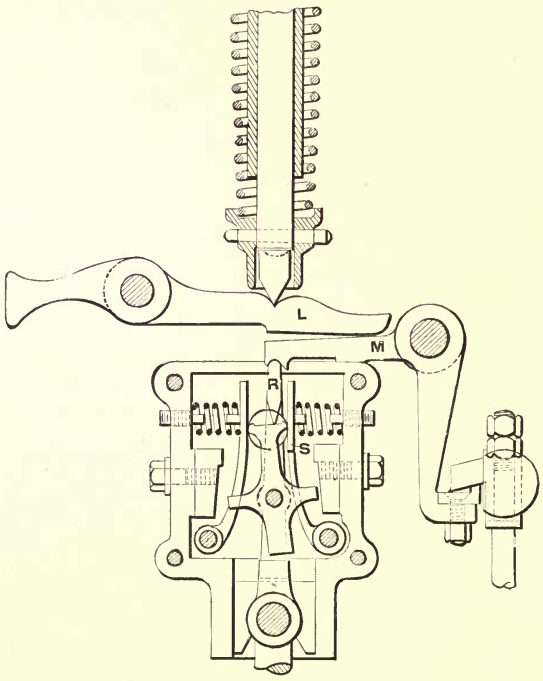


FIG. 56.—VALVE GEAR DETAIL OF CAPITAINE ENGINE.

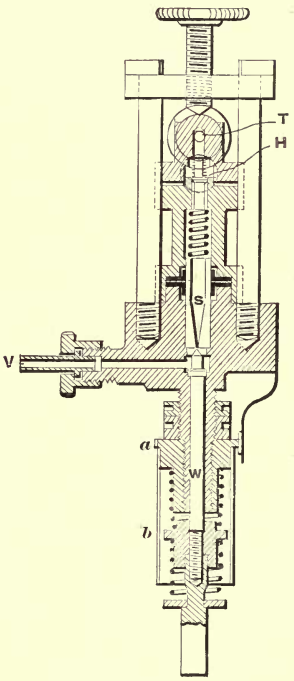


FIG. 57.—OIL PUMP OF CAPITAINE ENGINE.

the conical top point closes the bottom hole of the bucket S and carries the bucket before it, thus forcing the oil through the non-return valve H through T into the sprayer valve C of the vaporizer. On letting go the rod W, the non-return valve, the bucket, and rod will be pressed down by springs to their original position shown in Fig. 57. All parts of the pump can be easily got at after slacking the top screw and removing the traverse. The capacity of the pump is regulated by screwing up or down the nut *a*, thus limiting the stroke of the rod W, which is securely screwed to the nut *b*. When an engine of this kind is fitted to a launch, the pump is a suction and delivery pump of similar design, thus enabling the engine to pump oil from a tank below the pump. The vertical arm of the bell-crank ends in a detent which can be engaged by a corresponding detent N, Fig. 54, on a rod connected to the governor. The governor is carried in the fly-wheel, and transmits its motion through the boss to a sliding collar between the wheel and the bearing. A bell-crank and a rod connect the collar to the detent. The admission of oil is thus regulated by the governor according to the needs of the engine.

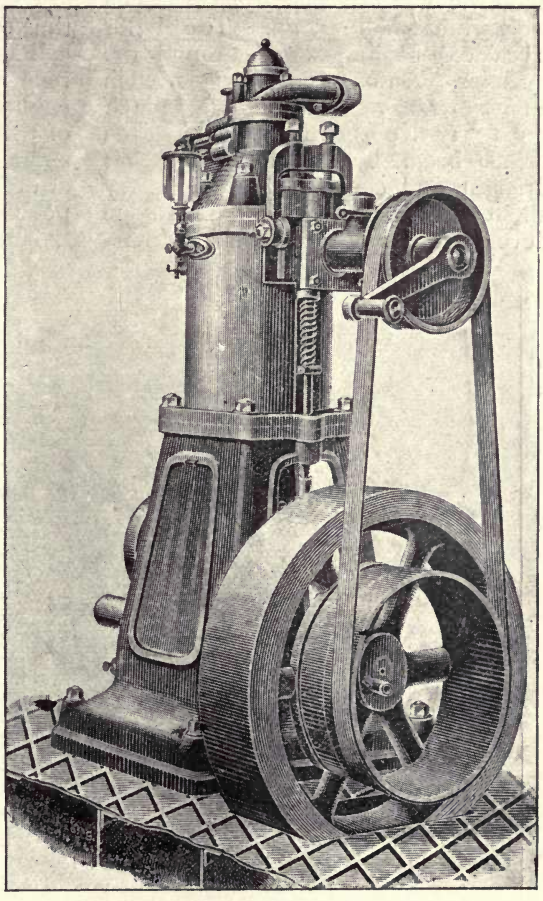


FIG. 58.—SINGLE-CYLINDER CAPITAINE LAUNCH ENGINE.

The operation of the engine is as follows: Explosion takes place with the piston on the top centre, after previous admission of oil-gas and air; the consequent impulse drives the piston down. On the upstroke the eccentric opens the exhaust valve and the burnt gases escape, the same movement of the eccentric also causing the feed pump to inject oil to the vaporizer. On the next down-stroke there is admission or suction of oil-gas and air; on this down-stroke and the next, the eccentric vibrating piece "misses," and on the upstroke the explosive charge is compressed, and when the piston is at top centre there is ignition and impulse. We thus have during two revolutions impulse, exhaust, admission of fresh charge, and compression. The exhaust pipe is connected to the chamber marked J in Fig. 54; Q and P in Fig. 55 are pipes leading from and to the water jacket surrounding the cylinder.

During the early part of last year a launch was on trial at Chester, England, fitted with one of the Capitaine engines, a friction gear being used for reversing or letting the engine run idly with the propeller shaft at rest.

The products of combustion from the cylinder were led to an exhaust chamber under a thwart, and from there were discharged under water. To the eccentric was attached a lever which worked a small pump. The latter circulated cooling water around the cylinder. An oil supply was carried in a tank in a bow chamber. The launch was thirty-five feet long by six feet ten inches beam by two feet six inches draught, and could comfortably carry about fifty passengers. The engine developed, as a maximum, six and one-half horse-power, and gave a speed of about eight and one-half knots an hour. The weight of the engine complete was about 2000 pounds. On the European continent launches propelled by these Capitaine motors are extensively used, especially at Hamburg, where a comparatively large number are at work.

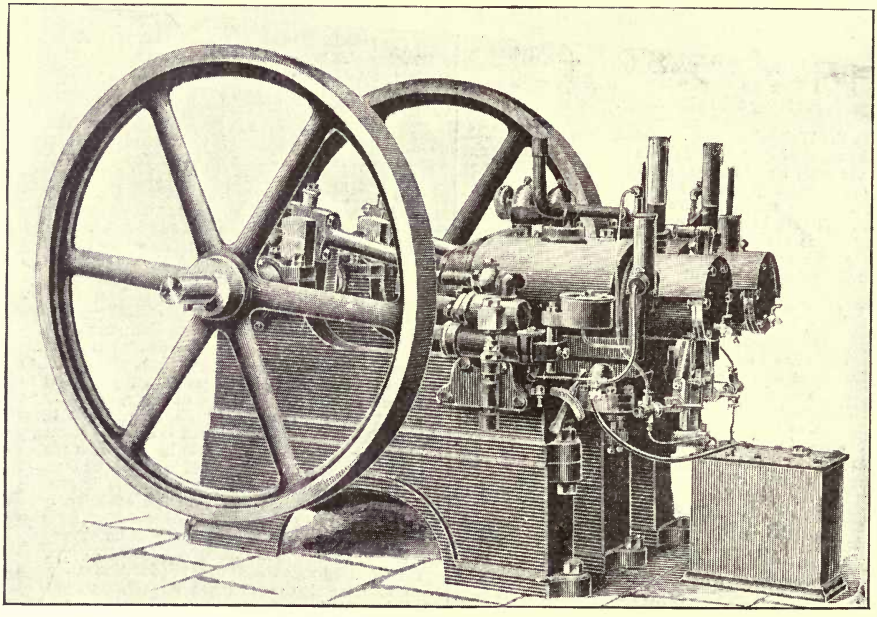


FIG. 59.—THE "TRUSTY" ENGINE, BUILT BY MESSRS. WEYMAN & HITCHCOCK, GUILDFORD, ENGLAND.

The "Trusty" petroleum engine, built by Messrs. Weyman & Hitchcock, Limited, of Guildford, England, is shown in Fig. 59, the illustration representing a view of a double-cylinder engine, though the firm make also a single cylinder engine. Both types work on the four-stroke, or Otto cycle. In the double-cylinder engine, it will be noticed, the cranks are set together, and one impulse is thus obtained at every revolution, the cylinders acting alternately. Ordinary, refined oil of commerce is used in the engine. The whole outfit is made up of the engine proper, a small oil pump, and a vaporizer, the last being arranged at the end of the cylinder. The oil is poured into a small tank, which is separate from the engine and can be placed in any convenient position in the engine room.

From this tank the oil passes to the pump through a small pipe, the pump being controlled by the governor. The requisite amount of oil is thus pumped into the vaporizer, and the vapor is drawn into the working cylinder during the suction stroke, mixing, in the cylinder, with a suitable proportion of air to make an explosive charge. Ignition of the charge is effected by an ordinary tube igniter kept hot by means of a small blow pipe flame.

The Brayton petroleum engine, shown in Fig. 60, has already been illustrated and described in a separate article in an earlier number of this magazine, but is here again incorporated for the sake of convenience and completeness. The illustrations, while showing one of the older types of Brayton engines, used with very good results in the United States, perfectly represent the principles of operation. The engine, as indicated by its name, belongs to the general class of petroleum engines, but in it no attempt is made to gasify or to vaporize, or even to heat the petroleum spray. The oil is finely divided—atomized in fact—in a large quantity of air, and is flashed into flame instantly. The combustion resembles that of flour dust or coal dust, suspended in the air, and which is so rapid that it constitutes an explosion. The combustible material is divided into infinitely small particles, and each particle is surrounded with an ample supply of oxygen, to which it exposes a surface which is very great in relation to its bulk. Under these conditions

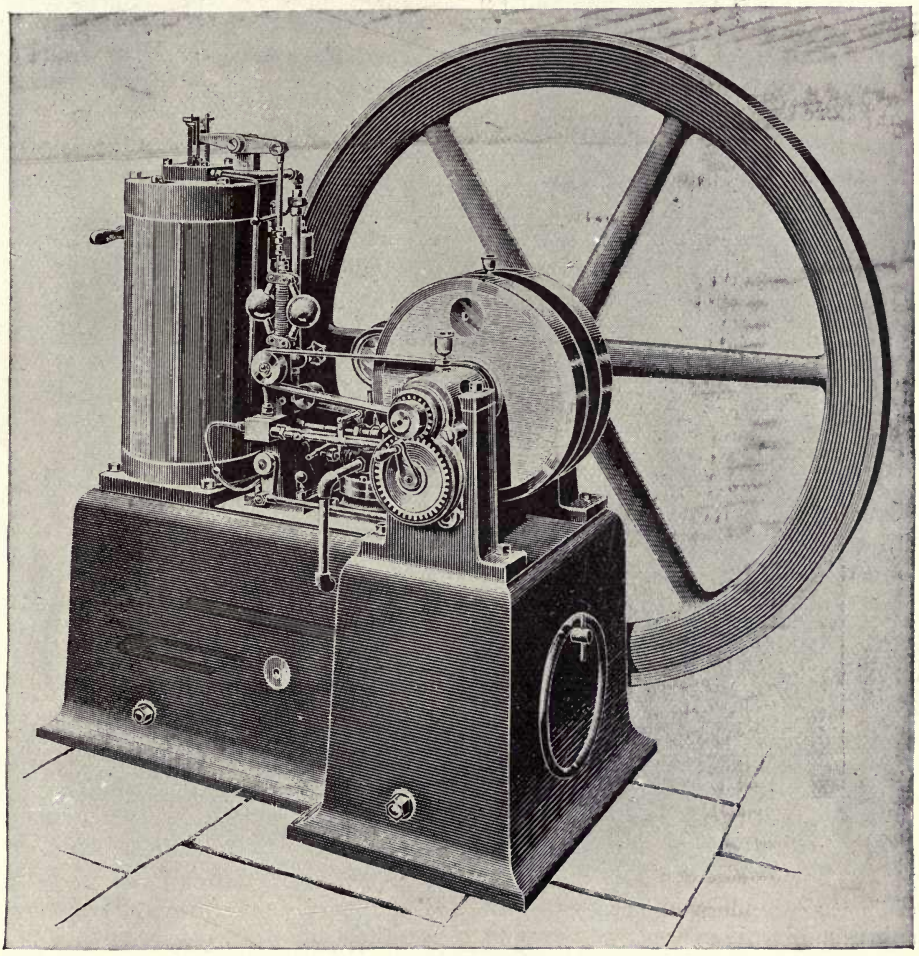


FIG. 60.—THE BRAYTON PETROLEUM ENGINE.

combustion is exceedingly rapid, and spreads from particle to particle with amazing celerity. The oil is burned suspended in air; its combustion is complete, and is not impaired or delayed by metallic surfaces on which deposit can accumulate.

The method of ignition is entirely novel. As the oil is not admitted till the moment of explosion, there is no question of "timing" valves, or of attaining a certain degree of compression before the charge can be fired. A platinum is maintained at a glowing temperature within the cylinder.

The engine works on a modification of the Otto cycle. Explosion, exhaust, suction, and compression follow each other in the usual order, but the suction is a suction of air only (not gas and air), and the compression, also a compression of air only. Further, the exhaust valve is held open during the early part of the compression stroke to "scavenge" the products of combustion out of the clearance space, and to re-

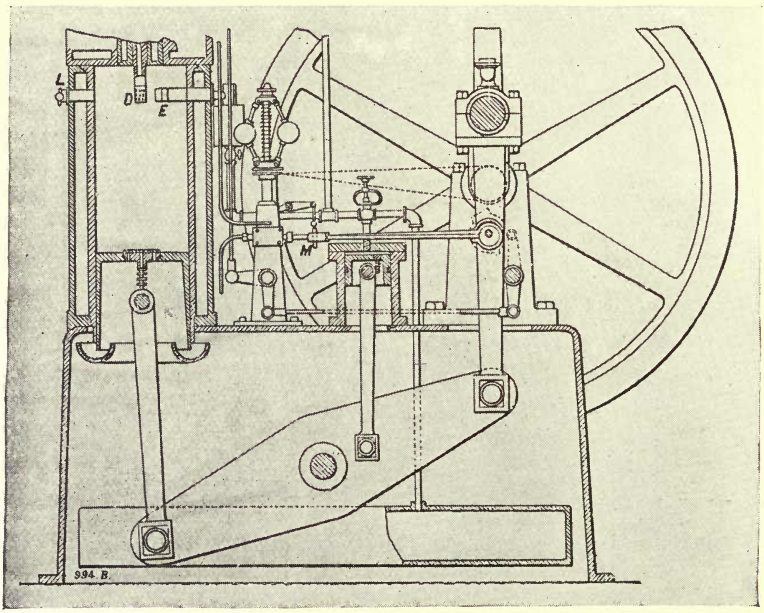


FIG. 61.—SECTIONAL VIEW OF BRAYTON ENGINE.

brilliantly incandescent surface can be maintained in the cylinder all the time, ready to ignite the first drop of oil that comes in contact with it. To do this, advantage is taken of the well-known phenomenon of flameless combustion, which is often shown on the lecture table, and but seldom found in practical work. A jet of air laden with hydrocarbon vapor is made to impinge continuously on a coil of platinum wire which has been previously heated, and as long as the jet is continued the place them by air. As the oil is sprayed into the compressed air in the cylinder it requires a blast of high-pressure air to effect its entrance. This air is obtained from a pump, which also supplies air to the incandescent burner, a pressure of eighty pounds to the square inch being employed for this purpose.

A sectional view of the engine is given in Fig. 61, while Fig. 62 shows some of the details. The general appearance of the engine is that of an inverted

beam engine, the beam being inclosed within the bed, and having a connecting rod at each end of it. From an intermediate point in the beam is worked the small pump which supplies the compressed air for spraying the charge and for maintaining the firing light. This pump is connected by a pipe to the cylinder head, shown on an enlarged scale in Fig. 62. The pipe A, together with the oil supply pipe B, to the sprayer D. The former consists of a tube in the end of which there are coils of platinum wire. These are separated from a packing of asbestos F by a perforated steel disc and a plate of wire gauze. A fine bore tube connects the firing device with the auxiliary oil reservoir G in which the oil is kept at a constant level by a float. Air from the pump is admitted to this reservoir by the pipe H ; part of it goes direct to

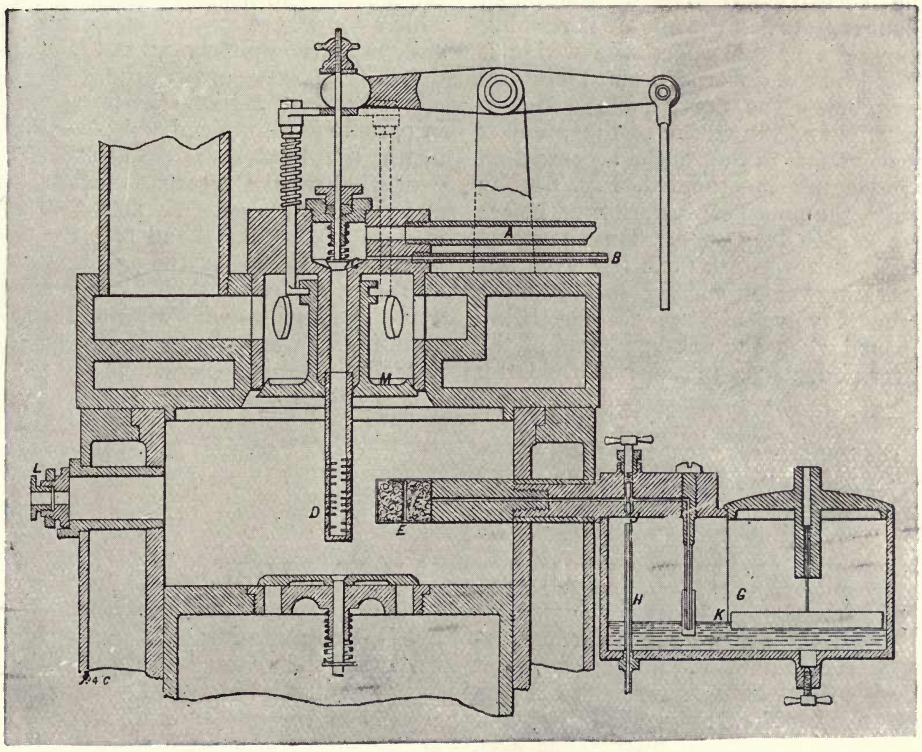


FIG. 62.—SECTIONAL VIEW OF BRAYTON ENGINE.

discharges into a chamber, the bottom of which is closed by a valve C. When this valve is lifted, the oil is driven violently down the pipe, and through the circumferential cuts at its lower end, into the clearance space of the cylinder. The oil is finely divided by the action of the blast and is driven out at several different levels in minute particles.

The igniting device E is placed near the platinum burner through the adjustable cock J and part through the device K. This latter consists of a perforated vessel having an internal pipe, the lip of which is below the oil level, so that oil and air are driven upon it in spray to the asbestos pad F. The heat of the cylinder continually vaporizes the petroleum in the asbestos, and insures it being carried forward in gaseous form to the platinum coils. In order to effect

the preliminary heating of the platinum, there is provided opposite to it a door L with a glass-covered aperture in its centre. This door is opened, and a torch is inserted by which the platinum is raised to a red heat.

The oil pump M, Fig. 61, is operated by an eccentric driven by one to two gearing from the crankshaft. The exact length of stroke of this pump is determined by a wedge, which occupies a position in a slot between the ends of the eccentric-rod and of the pump plunger. When the engine is running above the normal speed, the wedge is raised by the governor ; when it is running below the normal, the wedge is lowered and the stroke of the pump is nearly equal to that of the eccentric. A hand crank is provided, Fig. 60, by which the pump can be worked before the engine is started. On the same shaft with the eccentric is a cam for operating the oil inlet valve C, and the exhaust valve M, the former being opened when the left-hand end of the lever above it is raised, and the latter when it is depressed. The exhaust valve, as already stated, is opened at each revolution. It first evacuates the greater part of the products of combustion, and next it allows part of the air to blow through to scavenge the clearance space. This air is admitted by an automatic valve in the piston, Figs. 61 and 62, which opens as soon as a partial vacuum is formed in the cylinder. This position is chosen for the valve because the air can enter with little disturbance of the hot products of combustion, which congregate above, and can then sweep them completely out of the cylinder. To start the engine, the door L is opened and a torch of asbestos soaked in paraffin is introduced and placed beneath the burner E. When this is properly heated the torch is withdrawn and the door closed. A charge of oil is then injected by hand and the flywheel turned. On the compression stroke an explosion should occur, after which the engine runs without further attention. The cylinder is, of course, water-jacketed in the usual way.

(*To be continued.*)

THE FUTURE OF CAST STEEL.*

EVERY day we see a further development of the employment of the extra soft steel or homogeneous iron generally called cast steel. Without recounting all that has been said respecting the manufacture of this metal, it will be doubtless admitted that no metallurgical operation presents more precision or certainty than the working of the Martin furnace with basic or neutral hearth, or of the Thomas converter, which are the principal producing furnaces of cast steel.

In these days we no longer attach as much importance as in the past to the employment of very pure raw materials of well-known origin. Chemical analysis has taken the place of the foreman's eye in appreciating the purity and quality of the material used in working. What matters the quantity of phosphorus of the pig or scrap worked in the Martin furnace, since this phosphorus is sure to be eliminated in the course of working, thanks to a suitable addition of lime, which forms a basic slag capable of retaining the phosphoric acid proceeding from the oxidation of the phosphorus charged? We might say as much up to a certain point of the presence of sulphur. This substance, which very justly occupies the attention of manufacturers of soft steel, can now be very easily eliminated by a preliminary operation in the presence of manganese. The Martin furnace, with basic or neutral sole, is there-

* By permission of La Metallurgie.

MODERN GAS AND OIL ENGINES.

By Albert Spies, Mem. Am. Soc. M. E.

Fifth Paper.

A FIELD which almost from the beginning of the oil engine industry had suggested itself as a promising one for the extensive use of engines of that class is that of agricultural engineering. Steam engines have for quite a number of years been largely employed in agriculture, and have demonstrated conclusively that something more than man power has become necessary to economically carry on much of the farm work of the present day. For such work, however, steam engines have always carried with them the dangers of steam boilers, necessarily entrusted to the care of comparatively unskilled attendants, and it has become generally recognized that if some other, less dangerous source of power were available, it would be well worth having. Oil engines with their comparative simplicity and absence of complication in management appeared to exactly meet the requirements, and as a consequence portable outfits were built and are already much used for threshing and other similar purposes.

One of the makes which has become prominent in this line is the Hornsby-Akroyd oil engine, of which a portable form is shown in Fig. 64, while Fig. 63 represents the stationary design. It is built by Messrs. Richard Hornsby & Sons, Limited, of Grantham, England. The engine is horizontal and works on the well-known Otto cycle. It is constructed with a working cylinder closed at one end by a cover and open at the other. In this cylinder works the piston, which is formed like a plunger, being open at one end to receive the end of the connecting rod. Near the closed end of the cylinder a valve box is fitted, which contains two valves, one being the air valve and the other the exhaust valve. The air and the exhaust valves are operated by separate levers, each lever being moved by a cam mounted on a horizontal shaft, driven by the crankshaft through skew or bevel wheels. This horizontal shaft makes only one revolution while the crankshaft makes two, so that the air and exhaust valves are each opened only once in every two revolutions.

At the back of the cylinder is a cast-iron box, called the vaporizer, which is always open to the cylinder through a neck. This vaporizer is heated, before starting the engine, by an external lamp blown by a small fan for a few minutes, so that the vaporizer shall be able to vaporize and explode the oil when it is pumped into it. After the engine has started running, the lamp is no longer required, the vaporizer being kept hot enough by the explosions which take place in it.

A small oil pump worked by the air valve lever draws oil from the oil tank under the engine and forces it into the vaporizer ; this takes place only during the outstroke of the piston, when it is drawing in air. The oil on its way from the pump to the vaporizer passes through a valve box attached to the vaporizer. This valve box has two valves in it, one kept closed by a spring which the oil forces open as it goes into

the vaporizer. The other is also kept closed by a spring, and should the engine run too quickly, the governor opens it and allows some of the oil to flow back to the tank. This valve can also be opened by turning a little regulating handle, which will stop the supply of oil to the vaporizer, and thus stop the engine. The action of the engine may be explained as follows :

The vaporizer having been previously heated and the fly-wheel being pulled round, the first outstroke of the engine thus made will cause air to be drawn into the cylinder, and at the same time the pump will force oil into the vaporizer, which is immediately transformed into oil vapor. On the return stroke of the piston, the air is compressed into the vaporizer and thereby mixed with the oil vapor, and just as the piston gets to the end of its stroke, and the compression is, therefore, greatest, an explosion takes place, which forces the piston out on its second stroke. When the piston gets to the end of this stroke the exhaust valve opens, and the return stroke expels the gases, the same cycle of operations being repeated continuously.

The speed of the engine is governed by a small Porter governor which acts through levers on an overflow valve fitted in the valve box attached to the vaporizer, so that when the engine runs too quickly this valve is opened by the governor and the oil allowed to return to the tank instead of going into the vaporizer. The latter getting little or no oil, the speed of the engine is thus regulated.

The oil used for running these engines can be varied from oil of a specific gravity of .8 to one of .85 and even .88, with flashing points of from 200 to 250 degrees Fahrenheit.

The outline drawing, Fig. 65, will help to further explain the general construction and manner of working of the engine. In this, P represents the exhaust valve lever ; Q is the oil pump,

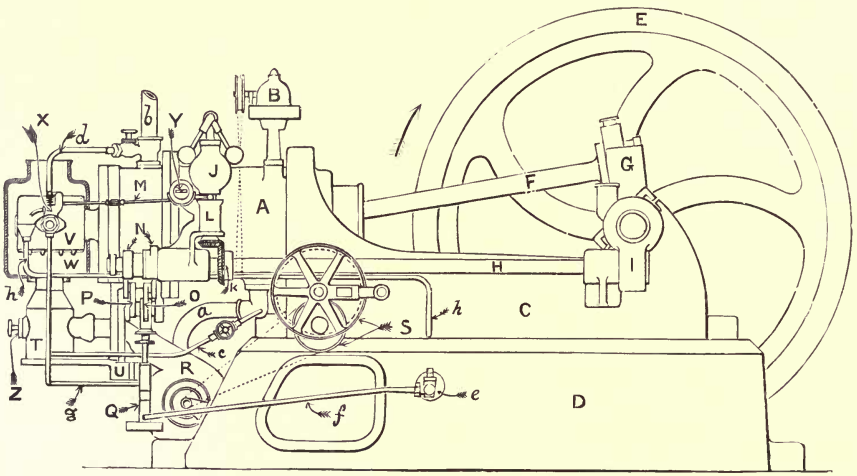


FIG. 65.—EXPLANATORY DIAGRAM OF HORNSBY-AKROYD ENGINE.

and R is the small fan referred to, driven from the pulleys S. The vaporizer lamp is shown at T, the vaporizer itself being marked V ; H is the cam shaft, and K are the governor gear wheels ; B is a cylinder oiler ; M is the connecting rod from the governor to the vaporizer valve box X. The water circulating pipes for the cylinder jacket are marked *a* and *b*, and those for the vaporizer valve box are marked *c* and *d*. The oil supply pipe *f* from the tank to the pump has a three-way cock *e* with a fitter inside ; *g* is the oil pipe from the pump to the vaporizer valve box, and *h* is the overflow pipe from the vaporizer valve box to the oil tank.

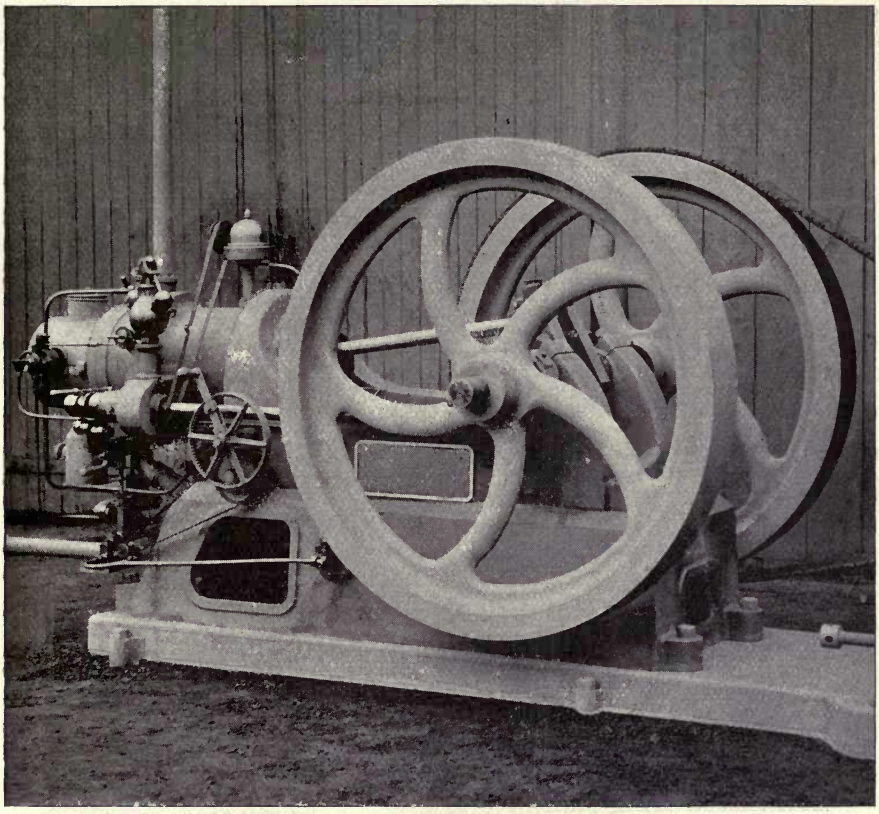


FIG. 63.—STATIONARY HORNSBY-AKROYD ENGINE.

The absence of all flame in this engine, after having started, is a striking feature, and is claimed to make the engine a peculiarly safe one. The engine is turned out in large numbers, and, like other engines of its class, is used for almost every purpose that power is required. The stationary motor is built in sizes of from one and one-half to nineteen actual horse-power, and the portable type, in sizes of from three and one-half to nineteen horse-power. In the portable type that which takes the place of the boiler is a water tank containing water for circulation through the engine cylinder jacket; that which takes the place of a smokestack is an exhaust silencing chamber, and that which takes the place of the fire-box is an oil tank. The outfit is thus remarkably independent and self-sufficing.

A somewhat similar portable oil engine outfit is that shown in Fig. 66, and built by Messrs. Robey & Co., of Lincoln, England. The engine in this case also works on the vaporizer system, oil being injected under pressure into an annular vaporizer chamber, heated only by the heat of combustion in the working cylinder. The governor also acts by determining whether the supply of oil shall go into the vaporizer or back into the oil supply tank. A heavy oil of about 0.85 specific gravity is used, with a flashing point of about 243 degrees Fahrenheit. The water tank contains sufficient water for circulation through the engine cylinder jacket for a whole day, and the oil tank is made large enough to hold a week's supply of oil. Robey & Co. make also a semi-portable engine of the same general design.

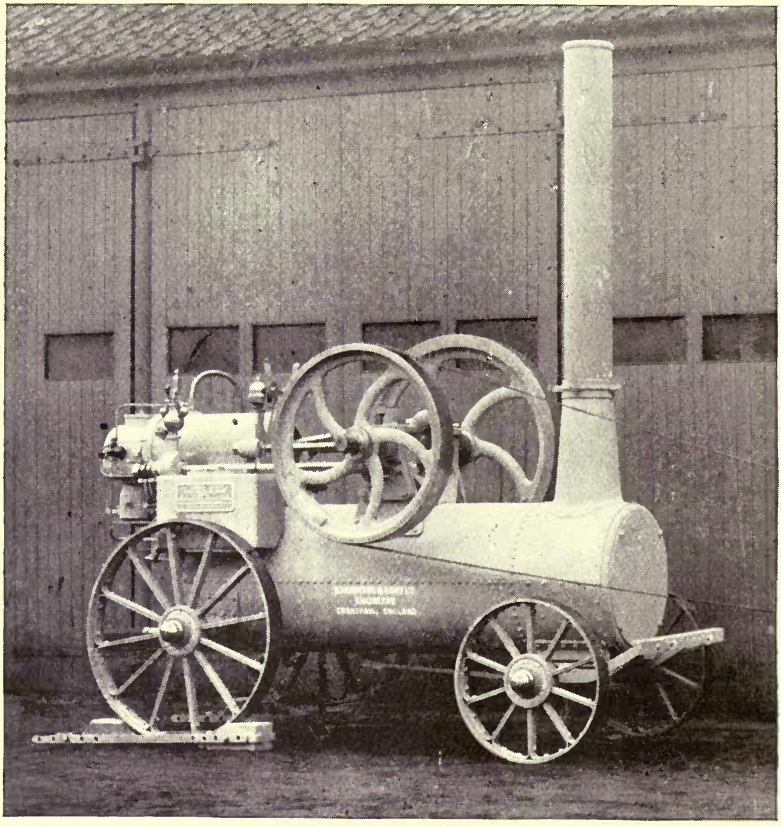


FIG. 64.—PORTABLE HORNSBY-AKROYD OIL ENGINE, BUILT BY RICHARD HORNSBY & SON, GRANTHAM, ENGLAND.

One of the American engines which has made rapid progress during the past few years is that built by the Van Duzen Gas and Gasoline Engine Company, of Cincinnati, O., and of which a number of different forms are shown. Altogether this company turns out seven styles: a simple stationary gas engine, a stationary gas and gasoline engine combined, a stationary gasoline engine, a portable gasoline engine, a stationary gas engine and pump combined, a stationary gasoline engine and pump combined, and a portable gasoline engine and pump combined. The gas and gasoline engine combined, as will be understood, may be used with gas alone, but has a gasoline apparatus attached to prevent any delays in operation should the gas supply suddenly fail. The portable gasoline engine is mounted on trucks, as the illustration shows, and may be used for driving threshing machines, hay presses, etc. The gas and gasoline engines and pumps combined, both stationary and portable, need no special explanation as to the uses to which they are to be put; the name sufficiently indicates the purposes to which they can be applied. In addition to the types already mentioned, the company also build a marine engine which appears to have met with much favor.

From the illustration of the horizontal stationary engine, Fig. 67, it will be observed that the cylinder, water jacket and pillow-blocks are all cast in one piece, and are supported by a cast-iron base. The four and five horse-power

engines carry one balance wheel, but those from seven horse-power up carry two such wheels. The four-stroke, or Otto, cycle of operation is followed. Between the cylinder and the base is a countershaft, worked by spur gearing from the crank shaft. On one end of this countershaft is mounted a cam for operating the exhaust valve, and on the other end are cams for similarly working the admission and ignition valves. The valves all are of the poppet type, and their stems are fitted with long guides. Figs. 69 and 70, which represent, respectively, side and end elevations of the engine, will help to explain the functions of the main parts.

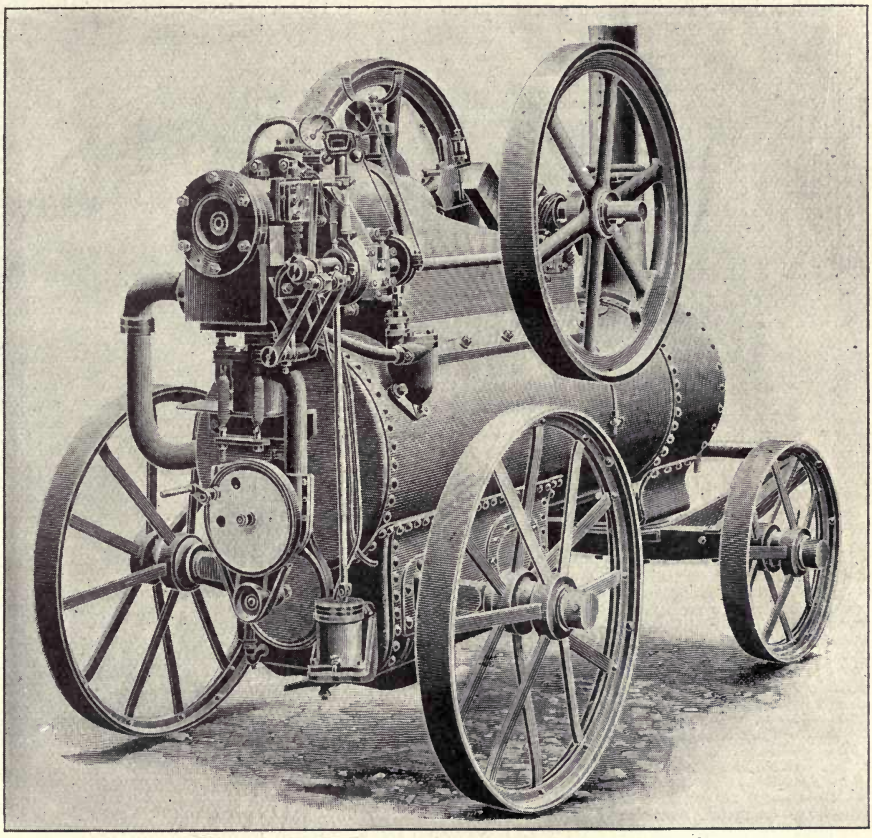


FIG. 66.—PORTABLE OIL ENGINE, BUILT BY ROBEY & CO., LINCOLN, ENGLAND.

To begin with, if the engine be below its normal speed, the governor rod D will allow the vibrating stem B to drop into such a position that the toe A will come in contact with it as soon as the rocker arm, marked 4, is raised. This arm begins to raise when the piston is at the end of its in-stroke, or when it is in the same position as that shown in Fig. 69. The cam marked 1, it will be noticed, is first about to come in contact with the cam roller 5 and the rocker arm 4. When it actually comes in contact with it and raises the arm 4, the toe A will be depressed, come in contact with the valve stem B, and open the admission valve C. By the time that the crank has come into the position B, corresponding to the end of the out-stroke of the piston, the valve C is again shut. The cams 1 and 3, working, respectively, the admission and the exhaust valves, are so designed as to

effect quick opening and shutting of valves, and also to keep them wide open during a large portion of the piston travel.

During the next half-revolution of the crank, from the position B back again to the position A, the mixture in the cylinder of the engine is compressed, and as the crank passes the inner centre, the cam, marked 2, comes in contact with the lower end of the two-armed lever E, and though it opens the other end of the cam shaft opens the exhaust valve, and allows it to close again when the crank finally resumes its initial position A. This completes a full working cycle, and everything is then in readiness to resume the same series of operations.

The end elevation, Fig. 70, shows, among other things, a vertical section of the carburettor. It consists of an iron casing with an inner tube through which the air necessary for the work-

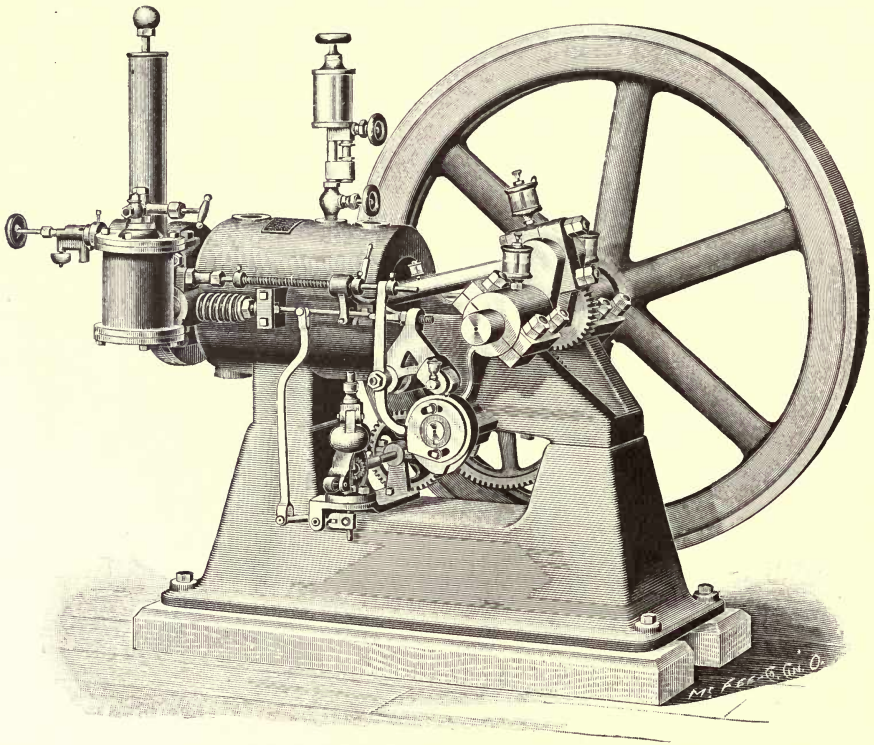


FIG. 67.—STATIONARY ENGINE, BUILT BY THE VAN DUZEN GAS AND GASOLINE ENGINE CO., CINCINNATI, OHIO.

the ignition valve N. The opening of this valve allows part of the explosive mixture from the cylinder to pass up into the ignition tube O. On the end of this tube is a ball H which is said to serve as a cushion, and to dispose of the waste gases which accumulate in the ignition tube. The mixture, being ignited, again forces the piston forward, bringing the crank once more into the position B. By this time the cam 3 on

ing charge enters. On top of this inner tube is seated a flange valve. As the air enters, it necessarily raises this valve which, in turn, raises the fluted stem of the check valve above it. The gasoline is in the chamber above this valve, and as soon as the valve is lifted the gasoline flows down inside the flange valve and out through the laterally disposed holes, as indicated by the arrows. Thence the gasoline flows

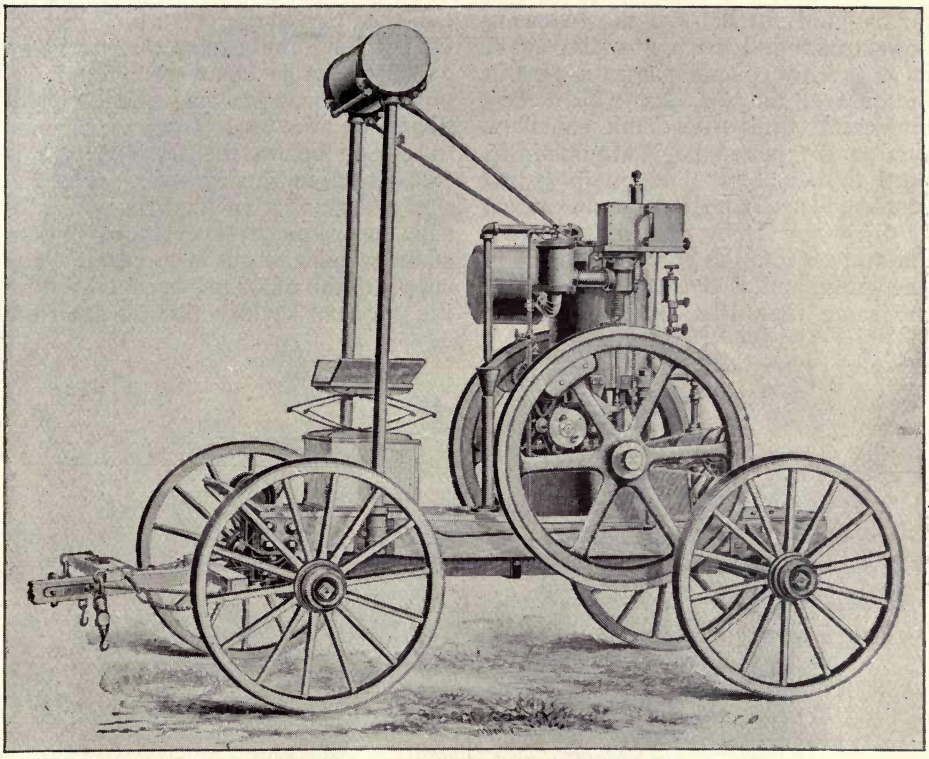


FIG. 68.—PORTABLE VAN DUZEN ENGINE.

over the edges of the air valve and is caught up by the air current flowing downward through the inner chamber and through a number of gauze rings, being vaporized on its way. It will be observed that no gasoline is allowed to enter the carburettor until the engine calls for it. From the carburettor the mixture goes immediately to the cylinder through the admission valve. Should any premature explosions occur, they would have to take place in the carburettor, and this is made strong enough to withstand them. As soon as the admission valve on the engine cylinder is closed, the air valve in the carburettor drops back on its seat, thus, in turn, allowing the gasoline check valve to drop back also, and effectively shutting off the gasoline supply. The gasoline tank necessarily is placed above the level of the top of the carburettor in order to allow the gasoline to flow to the latter by gravity.

The main features of the governor with which the engine is supplied are shown in the side elevation. The governor is worked from the crankshaft by intermediate gear wheels, and can be set to run at any desired speed. Changes of speed can be easily and quickly made.

Another engine of American design, more recently put on the market, is the Sintz engine, shown in Fig. 81, and built by the Sintz Gas Engine Company, of Grand Rapids, Mich. It is of the vertical type and is turned out both for gas and gasoline use. When gasoline is to be employed, the engine is provided with a small pump and is connected with a gasoline supply tank conveniently located. The operation of the engine is substantially as follows: When the piston makes its first upward stroke of the working cycle, it draws a charge of air into the crank casing with which, as will be noticed,

the engine is fitted. On the following downstroke, and when near the end of its stroke, the piston passes a port in the side of the cyiinder which communicates with the crank chamber. Just as the piston begins to open this port, the small gasoline pump (when gasoline is used) begins its downward or discharge stroke, causing the gasoline to pass into the port in the form of fine spray, and it finishes its stroke at the same time that the main piston this time performing a working stroke. On reaching the end of this stroke an exhaust port is uncovered, about opposite the transfer port already mentioned, and the waste gases are enabled to escape before the fresh charge is transferred to the cylinder. The design is such that an impulse, or explosion, takes place at every revolution while gasoline or gas is supplied. The supply of the oil or gas is controlled by the governor by its action on either the

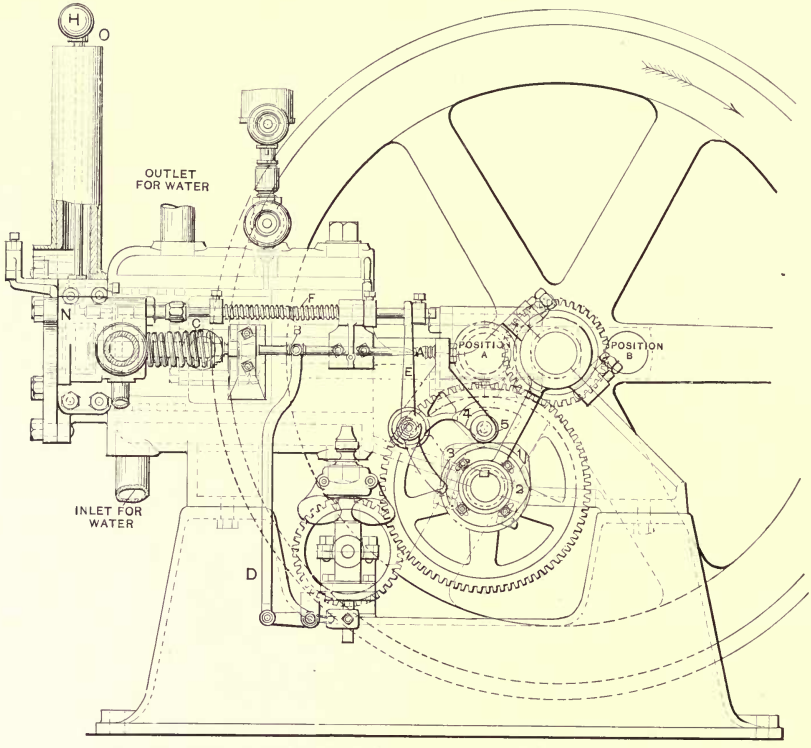


FIG. 69.—SIDE ELEVATION OF A HORIZONTAL VAN DUZEN ENGINE.

completes its downward stroke. In the meantime the air, which has been slightly compressed in the crank chamber, is rushing through the port, and is deflected to the top of the cylinder, carrying the gasoline with it, and forming an explosive mixture.

The piston, on its next upward stroke, compresses the charge in the upper end of the cylinder where it is ignited electrically at the proper moment and drives the piston down again, gasoline pump or on the gas valve, depending upon the kind of fluid used.

A special marine engine outfit is made by the builders, the engine itself being of substantially the same design as that shown. Both the marine and the stationary engines are made in sizes of from one to fifteen horse-power.

The "Forward" gas engine, an English design, built by Messrs. T. B. Barker & Co. of Birmingham, is shown in Figs. 76 and 77, the former repre-

senting the type followed in engines up to nine horse-power, having a single fly-wheel, while the latter shows an engine with two fly-wheels of the kind turned out in sizes of from twelve to twenty horse-power. The engine follows the Otto cycle in its operation, working ordinarily, with one explosion in every two revolutions, the number of explosions, however, being reduced, as in many other engines, by the action of the governor when the engine is running with a light load. The principal feature of interest in the engine is the application, to the larger sizes, of a starting gear invented by Mr. F. W. Lanchester, and which adds nothing to the bulk or complexity of the engine, at the same time answering its purpose admirably, and making the engine as easy to handle as an ordinary steam engine. A sectional view of this starting gear is given in Fig. 79 The method of operation of the attachment is extremely simple.

Gas is allowed to blow into and through the cylinder until an explosive mixture is created within it, the condition of the mixture being judged by the color of the flame produced by allowing it to blow through an external pilot jet. At the right moment the gas is shut off and the flame strikes back through the blow-off cock, causing an

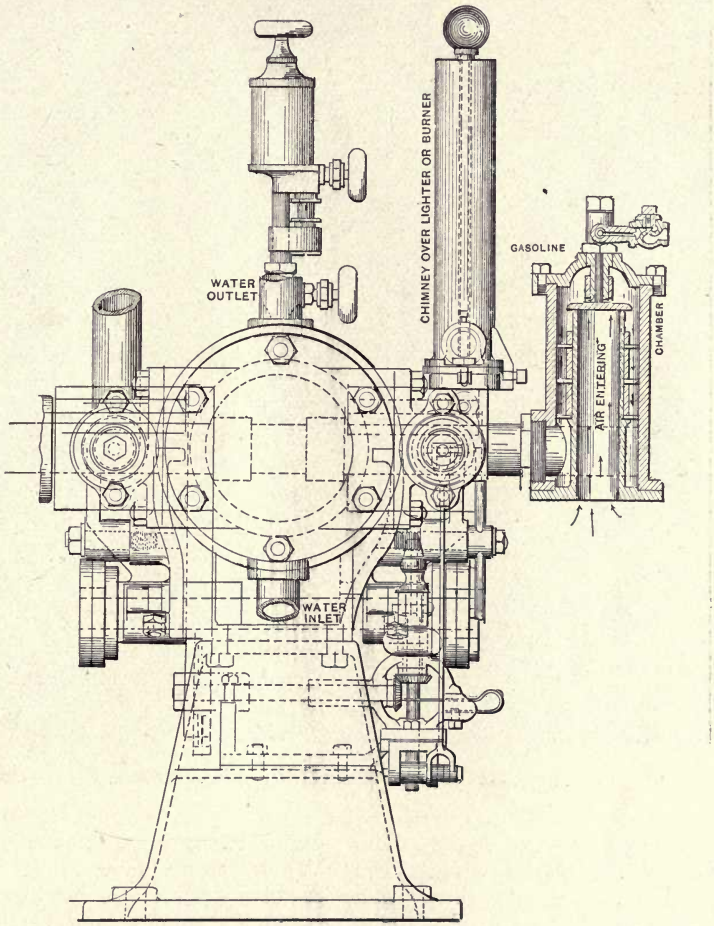


FIG. 70.—END ELEVATION OF VAN DUZEN ENGINE.

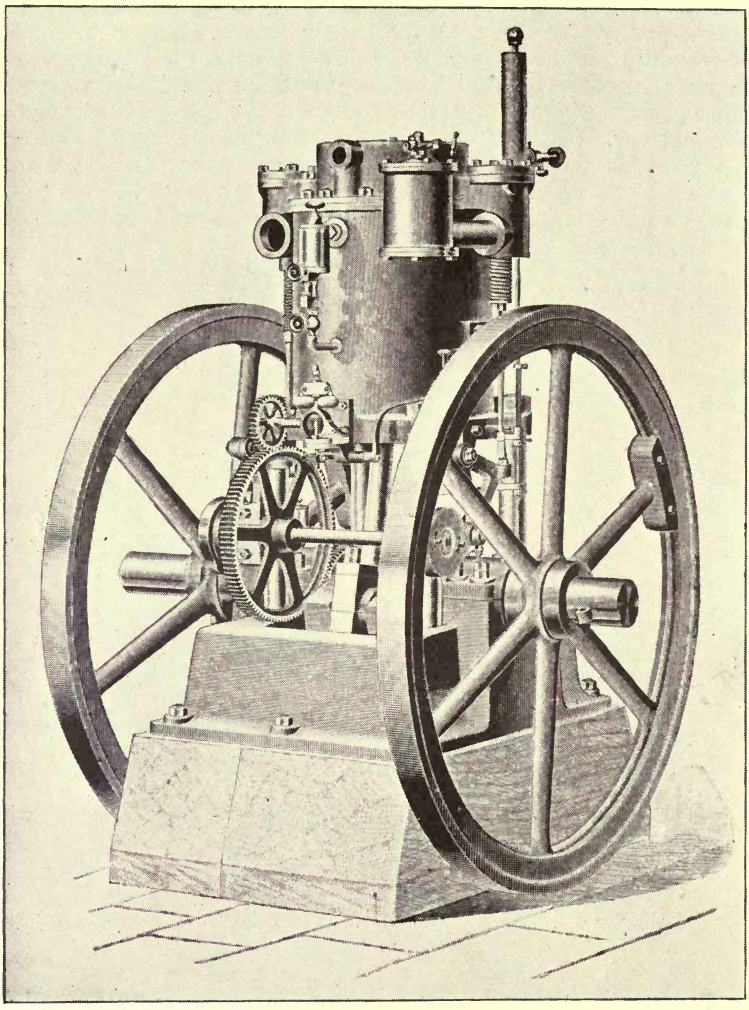


FIG. 71.—LARGE SIZE VERTICAL VAN DUZEN ENGINE.

explosion which starts the engine. The back stroke of the piston exhausts the gases, and the next stroke draws in a charge in the usual way ; it also sucks in the pilot flame through the blow-off cock, and fires the charge, the engine thus temporarily working on the Lenoir cycle, explained in the first paper, with an explosion at each revolution. Under these conditions a speed of 120 revolutions per minute is gained in a few seconds. A certain speed, less than 120 revolutions, however, is needed to insure a compressed charge exploded by an incandescent tube. When the requisite speed is attained, the blow-off is closed, and the cam set to exhaust every second revolution ; the engine then works compressively and fires its charge from the hot tube. In the diagram *j* is the gas nozzle, *f* the blow-through cock containing a lightly loaded non-return valve which closes at the explosion, *d* the outlet, *c* the pilot flame, *h* the gas pipe, *e* the exhaust valve, and *m* the exhaust cam.

It is interesting to note that besides having been applied to the "Forward"

gas engines for some time past, the apparatus has also been used with success on engines of other makers.

The Trent gas engine, shown in perspective in Fig. 72, is a single acting engine, receiving one impulse for every revolution, and is made by the Trent Gas Engine Company, Limited, of Nottingham, England. Sectional views of the cylinder are given in Fig. 75. The cylinder, as shown, is of two different diameters and contains the double-headed piston B D. When this piston makes its outstroke, gas and air are drawn in through a simple steel valve E. On the instroke of the piston this valve is closed mechanically and the mixture of gas and air is forced through the valve O into the explosion chamber M, where it is compressed, driving before it the exhaust gases remaining from the previous explosion which escape through the valve R, and is then ignited. The resulting explosion drives the piston outward, and the acquired momentum of the fly-wheel performs the next instroke. The valves are worked by cams on the crankshaft, and the gas supply is regulated by a hit-and-miss device controlled by a centrifugal governor. Firing of the gas and air charge is effected by a tube igniter. The engine is built in sizes of from one-half to 100 horse-power, and has done some good work in electric lighting.

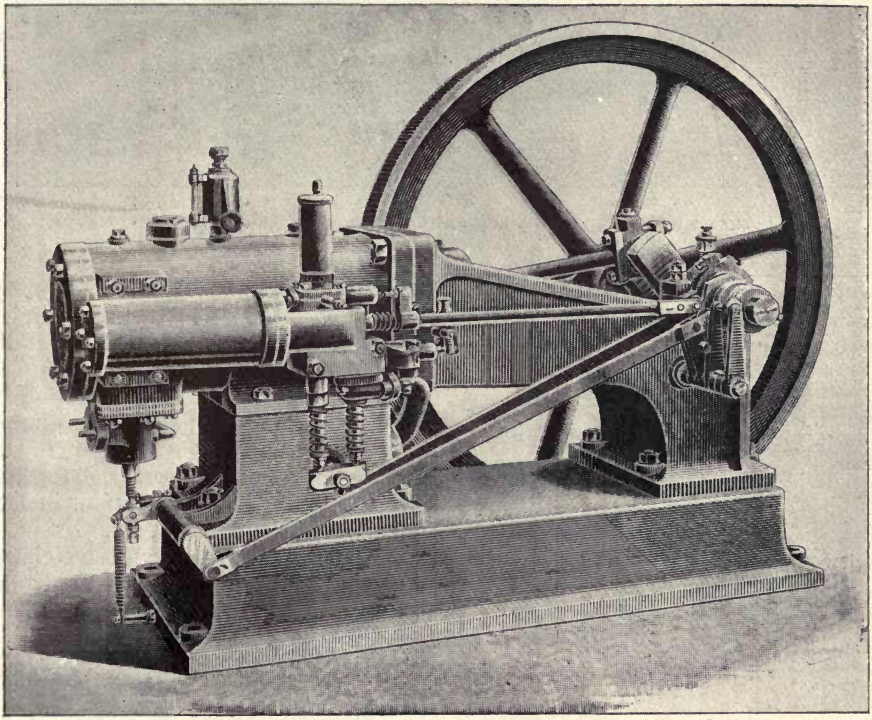


FIG. 72.—THE TRENT GAS ENGINE, BUILT BY THE TRENT GAS ENGINE CO., NOTTINGHAM, ENGLAND.

A gas engine, somewhat unusual in appearance, reminding one of a steeple compound steam engine, is made by the Hicks Gas Engine Works, of Cleveland, O., and is shown in Fig. 80. The two cylinders are set in line, one above the other, and are arranged to work alternately, so that practically there is one effective impulse for every revolution of the crankshaft, the Otto working cycle being followed in each

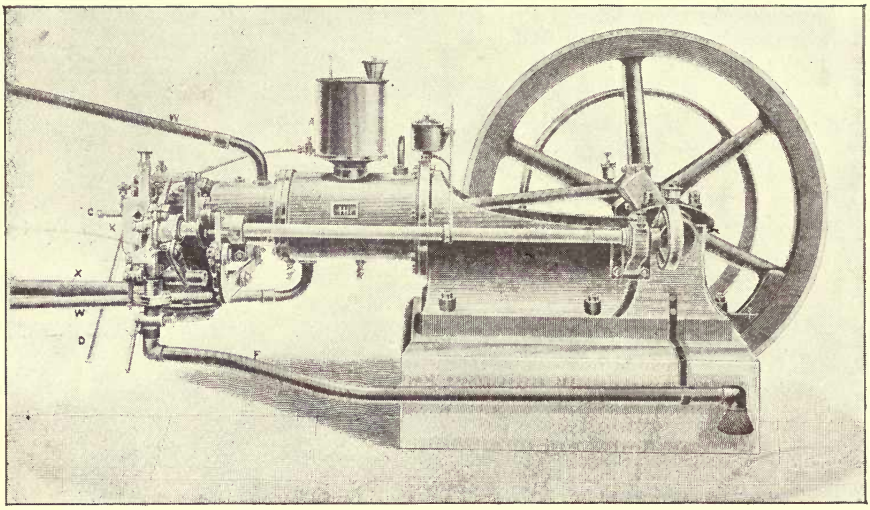


FIG. 73.—THE ROCKET PETROLEUM ENGINE, BUILT BY ROBERT STEPHENSON & CO., NEWCASTLE, ENGLAND

cylinder. Compared with a single cylinder gas engine, therefore, we find in this case, for the same sets of conditions, that the power of the engine is doubled, while the additional weight consists only of the weight of one cylinder and its piston. Another advantage of the two alternately working cylinders is found in the circumstance that the weight of the fly-wheel may be reduced considerably without unfavorably affecting the regular running of the engine. The design and construction of the engine are very simple and call for little explanation. The illustration, in fact, tells almost the whole story.

The amount of the explosive charge admitted to the cylinders is controlled by a governor as in a steam engine, the governor either throttling the supply or opening the valve wide, according to the demand for power. All the

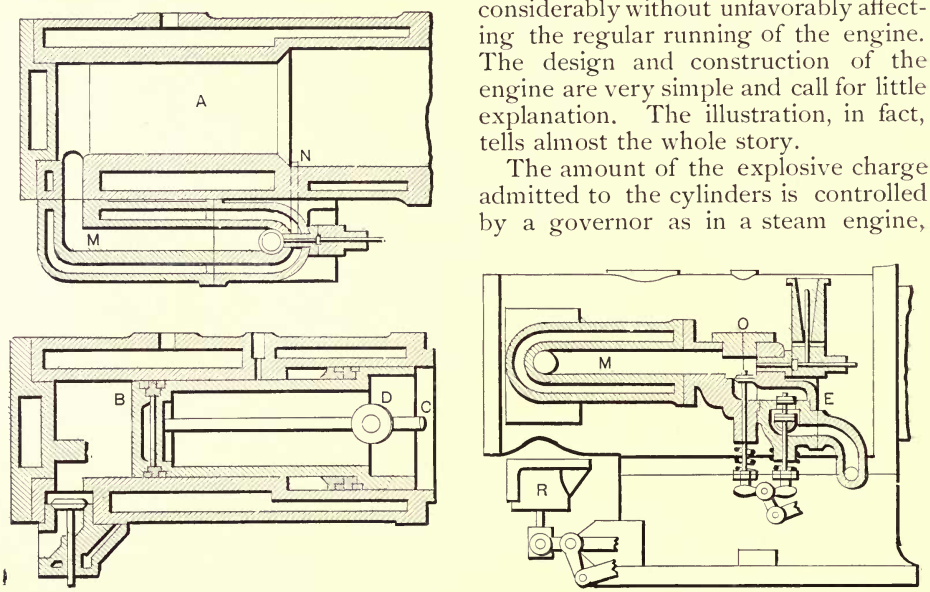


FIG 75.—SECTIONAL VIEWS OF THE TRENT ENGINE.

valves used are of the lift type. The exhaust valves, shown on the left of the cylinders, are worked by rods and tappets, and these, in turn, are moved by suitable cams carried on a small shaft in back of the engine frame. The cam shaft is driven from the main shaft through intervening gear wheels of such diameters that its speed is reduced

Robert Stephenson & Co. of Newcastle-on-Tyne, England, under the patents of E. Kaselowsky. The engine works on the well-known four stroke cycle. The governing arrangement is such that the supply of explosive vapor is entirely cut off when the speed of the engine runs above the normal, and with the exercise of the governor in this way

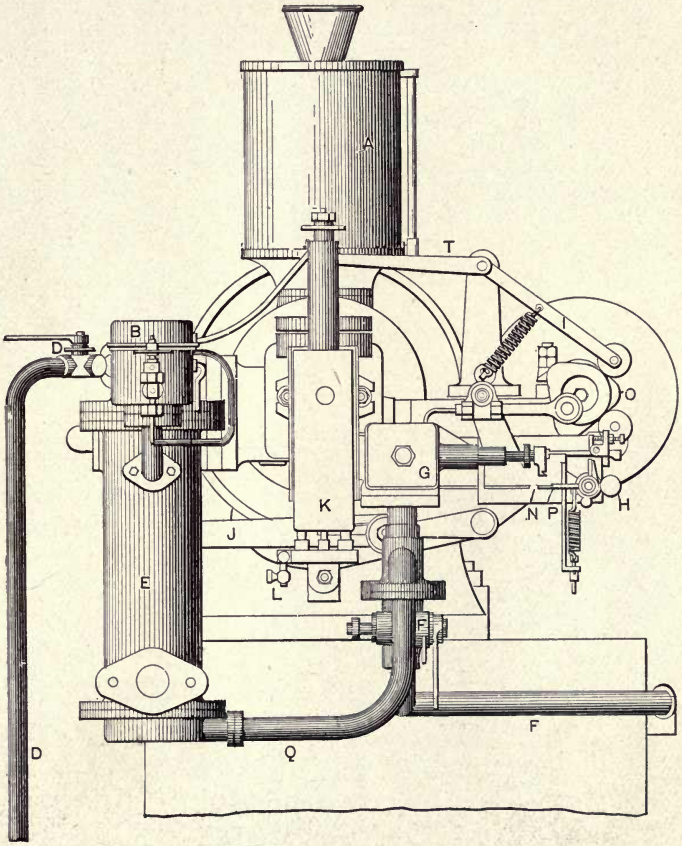


FIG. 74.—END VIEW OF "ROCKET" OIL ENGINE.

one-half. Gasoline as well as gas may be used in operating the engine, the former, however, naturally calling for the addition of a carburetting apparatus of some kind.

A petroleum engine, which by its name as by its builders, recalls the early days of the locomotive, is shown in Figs. 73 and 74. It is called the "Rocket," and is made by Messrs.

a lever acts simultaneously to relieve the compression of the waste gases in the cylinder, thus helping to make the speed more regular. Sufficient oil for a day's work can be stored in a tank fixed above the cylinder, from which it is allowed to flow by gravity into a lower receiver. In this latter there is a float regulating the supply. The firing of the charge is effected by an

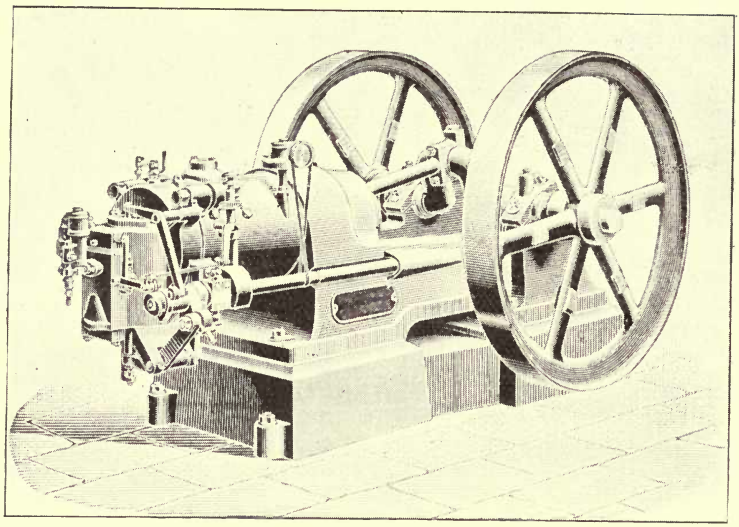


FIG. 77.—DOUBLE FLY-WHEEL "FORWARD" ENGINE.

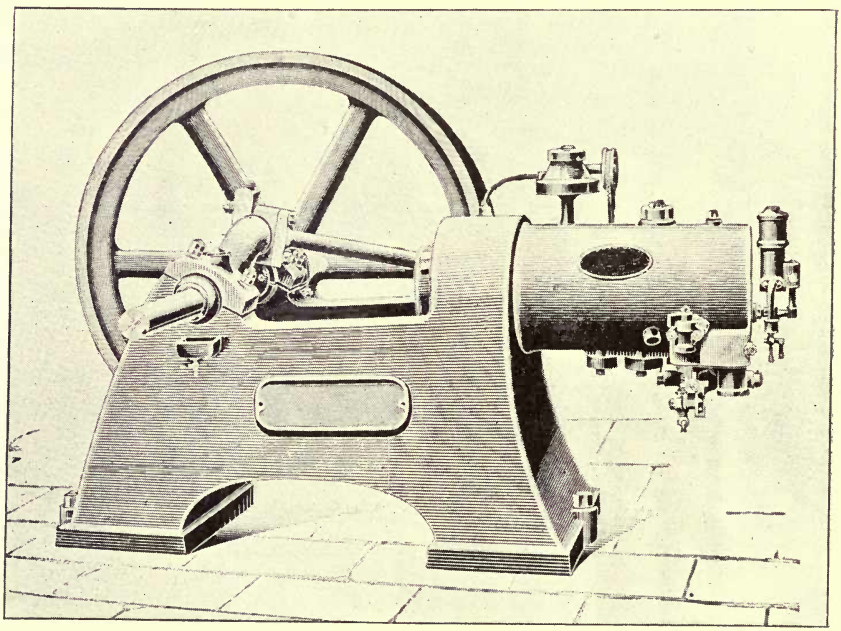


FIG. 76.—THE "FORWARD" ENGINE, BUILT BY T. B. BARKER & CO., BIRMINGHAM, ENGLAND.

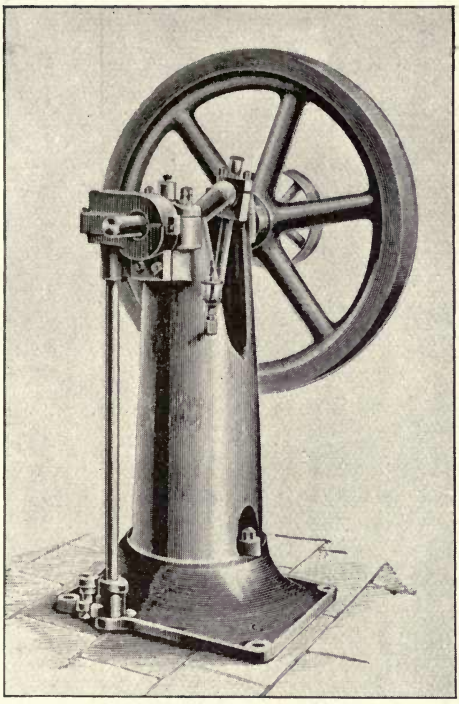


FIG. 78.—VERTICAL "FORWARD" ENGINE.

ignition tube with a timing valve worked by the lever I and cam O. Compression in the cylinder is diminished by keeping the exhaust open when the engine is being started, and one man can, therefore, easily turn the engine over. The oil used is ordinary lamp oil.

From the oil tank A the oil, as just stated, flows to the lower receiver B, and from the latter it passes through the regulator and into the top of the vaporizer E. In this the oil is sprayed by an air current and passes through tubes in the vaporizer, which forms an enlargement of the exhaust pipe. The bottom of the vaporizer is heated by a lamp flame for starting, but after the engine is once in operation the exhaust gases perform the heating. The main air admission pipe is marked F and is provided with a regulating cock, F^1. Air is also admitted to the vaporizer through the pipe D, which, similarly, has a regulating valve.

The sprayed oil is converted into vapor in its downward travel through

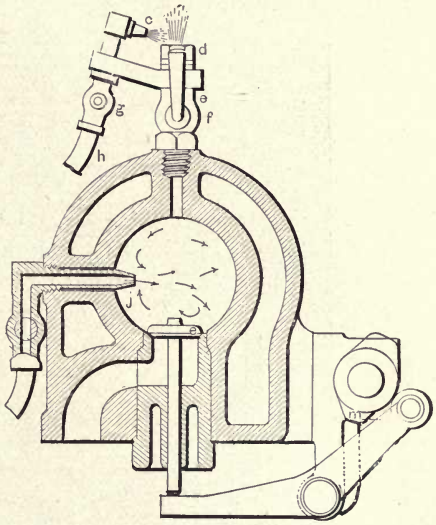


FIG. 79.—LANCHESTER'S STARTING GEAR.

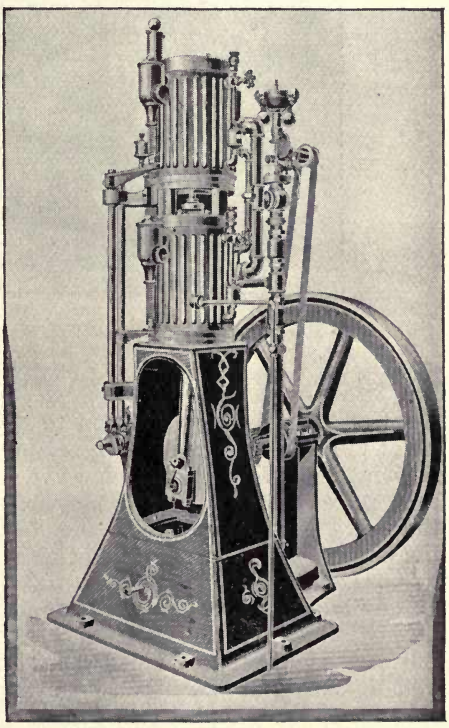


FIG. 80.—THE HICKS GAS ENGINE, BUILT BY THE HICKS GAS ENGINE WORKS, CLEVELAND, OHIO.

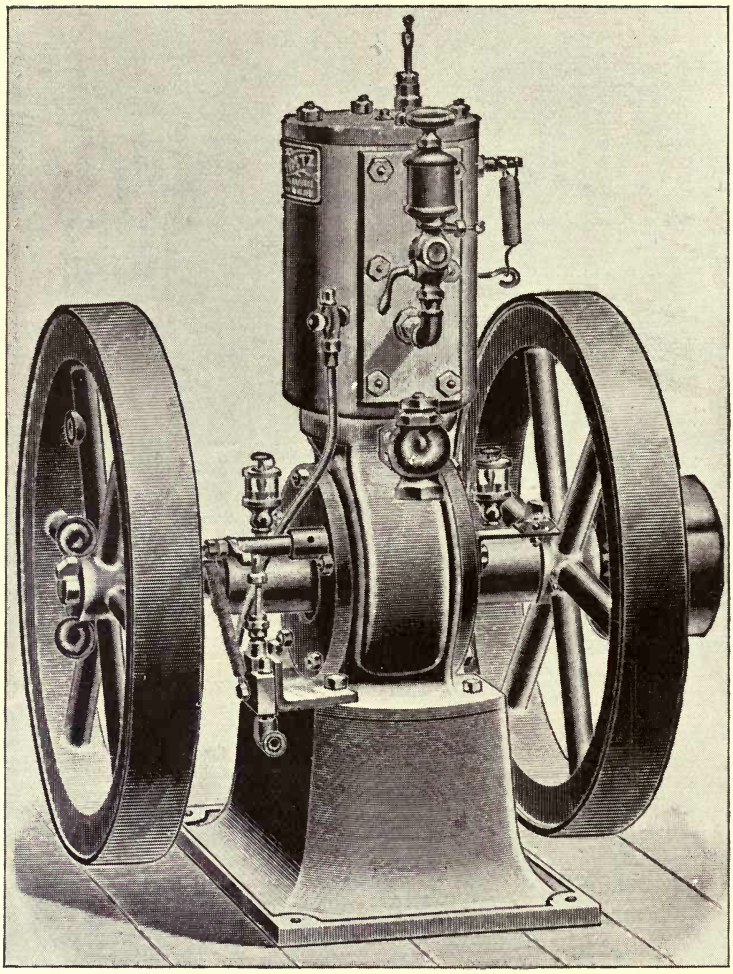


FIG. 81.—THE SINTZ ENGINE, BUILT BY THE SINTZ GAS ENGINE COMPANY, GRAND RAPIDS, MICH.

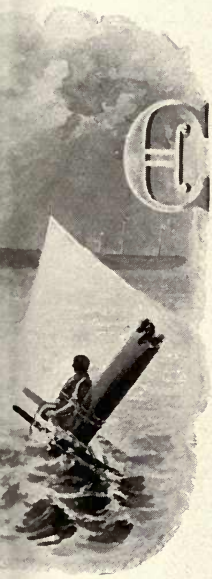
the vaporizer, and, in addition to the air of the spraying current, takes in a further supply through the pipe D. It then passes into the pipe issuing from the bottom of the vaporizer and joins the main air inlet pipe at a point above the cock F^1. From this point it finds its way into the cylinder of the engine through a valve, G, controlled by the governor H, trip P and notch piece N. When the engine runs too fast the spindle of the admission valve G is missed, and another valve, not shown in the illustration, is opened to allow the gas contents of the cylinder to escape. The exhaust valve lever is shown at J; W and W^1 are water circulating pipes for the cylinder jacket, and X is the exhaust pipe. The ignition tube is surrounded by a case, K, and L is the oil and air admission pipe for the heating flame. The engine is made in sizes of from one to ten horse-power.

(To be continued.)

MODERN GAS AND OIL ENGINES

By Albert Spies, Mem. Am. Soc. M. E.

Sixth Paper.



EVER since the first practical utilization of gas and oil engines and the satisfactory demonstration of their applicability to general power purposes, builders of such engines have sought to cultivate special fields in which to secure new employment for the motors and, as a consequence, they are found at the present time performing the widest variety of services. Not only as stationary, but also as portable engines, mounted on trucks, for agricultural purposes, as fire engines, pumping engines capable of being rapidly taken from place to place, as locomotive engines driving road carriages, and as marine engines for propelling launches, as instanced repeatedly in the preceding papers, they are successfully used. In fact, there is no line of work that can be readily called to mind in which they are not now either successfully operated, or to which they do not promise to lend themselves with satisfaction. They are no longer the clattering, noisy engines of early years, nor have they retained the excessive bulk and great weight for even moderate powers which characterized some of them when first brought out; instead, they have been made surprisingly quiet in operation, and in size and weight have been brought down almost to the figures ruling in steam engine practice, so that, for the same powers, a modern gas or oil engine and an average steam engine are not very unlike.

Among the many oil engines which probably first became best known in the United States as specially applicable to launch propulsion is the Daimler motor, built in this country by the Daimler Motor Company, of Steinway, Long Island City, N. Y., and introduced also in England by Messrs. Sims & Co., of London. The engine is designed for the use of either gas or gasoline, and is the invention of Mr. Gottlieb Daimler, of Cannstatt, Germany, who for many years was associated with the late Dr. Otto. It is by no means, however, restricted to launch use, but is applicable to all the several motor purposes for which the various engines of its class have been employed. Figs. 82 and 83 represent different views of a single-cylinder Daimler motor, while Fig. 84 shows a double-cylinder design, the motor, it being proper to state here, being made with one or more cylinders according to the power required. Thus, while the smaller sizes are of the single and double-cylinder designs here illustrated, the five and ten-horse-power engines have four cylinders placed side by side.

The principle of operation, however, and the main features of construction are the same in all the engines. For the purpose of our explanation of the manner of working we will take the single-cylinder engine, the cycle of operations applying equally well to all the others, being simply multiplied in number with the increase in the number of working cylinders. Fig. 87 represents a vertical section of one of the engines along the line of the shaft and clearly illustrates the character of the internal construction, the valve mechanism, governor connection and other important working details. Within the

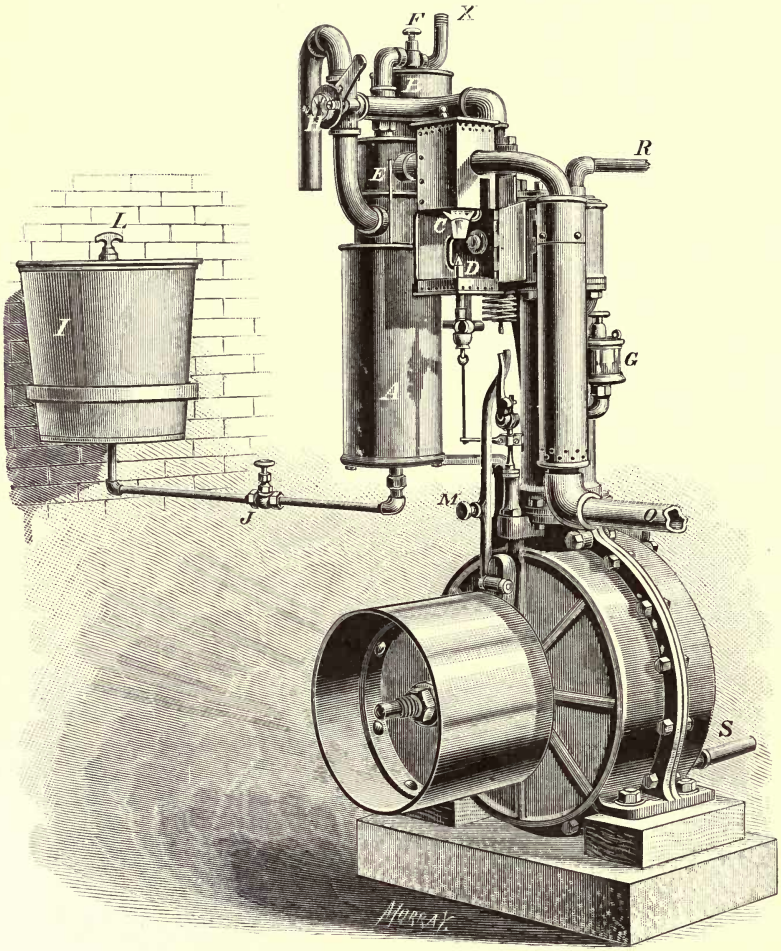


FIG. 82.—SINGLE CYLINDER MOTOR, BUILT BY THE DAIMLER MOTOR COMPANY, NEW YORK.

base of the motor, which consists of a cast iron circular chamber, are arranged two crank discs, mounted upon the two sections of the main shaft and connected by the crank pin, the crank discs serving also the purpose of fly wheels. In one of the discs is formed a double cam groove which passes twice around the crank-shaft and returns into itself. In this cam groove works a follower, or two followers in the case of a double-cylinder engine (see Fig. 85), operating the exhaust valve gear so as to make every other stroke a working stroke, and thus maintaining the Otto cycle. When two or more cylinders are used, they are arranged either parallel with one another, or they are inclined so as to form a slight angle. In the double-cylinder engine both connecting rods work on the same crank pin, and both pistons, therefore, move up and down together; but on the down-stroke one of them is always moving under the impulse of an explosion, while the other is drawing a working charge into its cylinder, and on the up-stroke one of them is always expelling the waste gases, while the other is compressing a charge. Ordinarily, therefore, there is in the double-cylinder engine an explosion in either one or the other cylinder

at every revolution of the crank-shaft. In the engine as arranged for working with gasoline, A (see Fig. 82) is the carburetor; O is the exhaust pipe which is provided with a perforated casing through which the air is drawn on its way to the carburetor, becomes warmed before it reaches the latter, and is thus better able to become impregnated with gasoline vapor. From the carburetor the mixture goes through the valve H which also admits an additional air supply through the open-end, curved pipe, shown at the left, and the charge finally reaches the valve chamber. The small valve F regulates the supply of gasoline to the burner D which heats a platinum ignition tube C. With this ignition tube heated to redness and a few turns given to the engine by means of the crank handle S to draw in the initial working charges, the engine will proceed regularly with its work. A vertical section of the cylinder, valves and crank chamber is given in Fig. 86. The admission valve is held to its seat by a spring and opens inward under the influence of the partial vacuum formed in the cylinder by the suction stroke of the piston. The exhaust valve is similarly kept closed by a spring while the admission valve is open, and is pushed upward and opened to permit escape of the waste gases from the cylinder at the

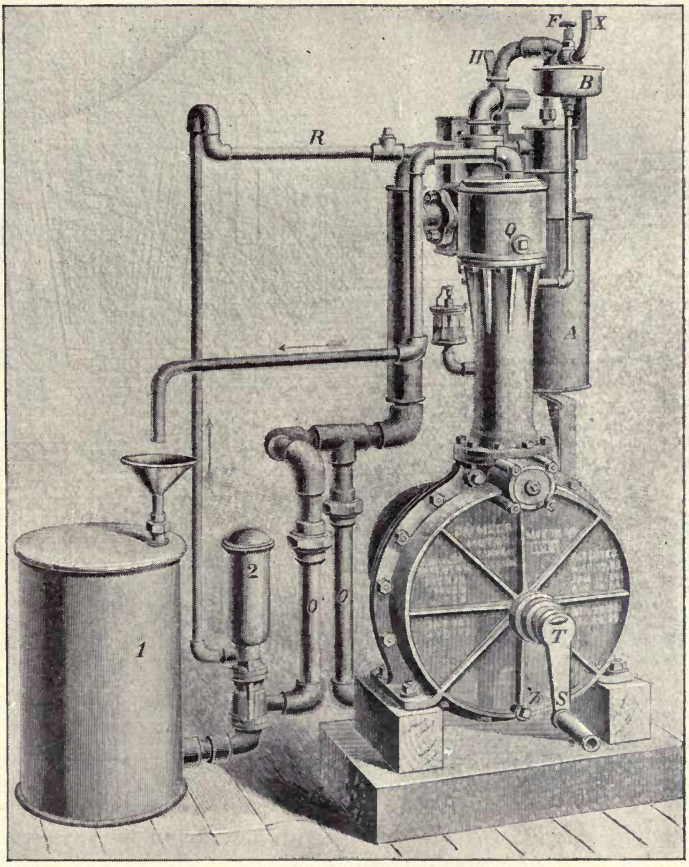
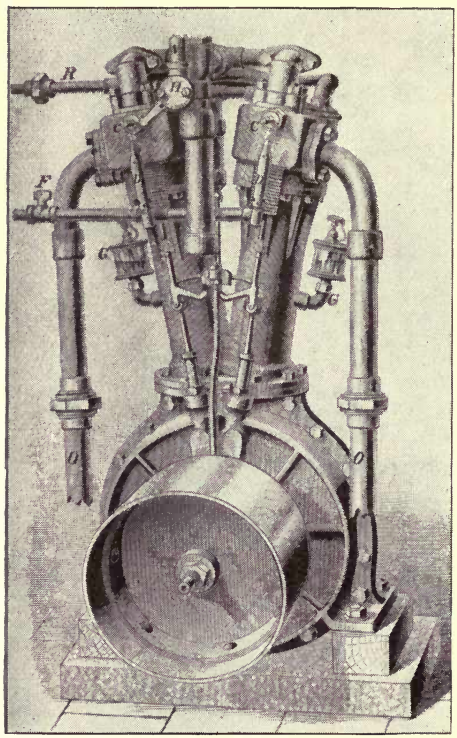
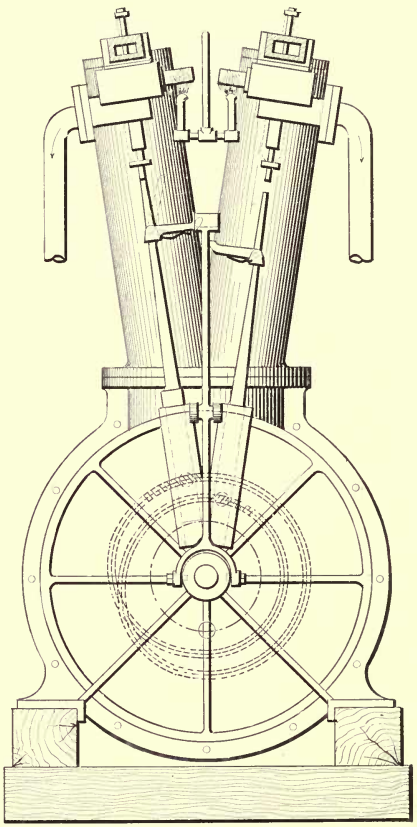


FIG. 83.—SINGLE-CYLINDER DAIMLER MOTOR, WITH COOLING WATER CIRCULATING PUMP.

proper time by the exhaust valve rod which is operated, as previously remarked, by the follower working in the cam groove in one of the crank discs. The governor arrangement is exceedingly neat and simple. The governor, it will be seen, is mounted inside the driving pulley on the crank-shaft, and by means of a sliding collar controls the position of a centrally pivoted rod. When the speed of the engine rises above the normal, the governor weights move outward, carry the sliding collar along the shaft, and deflect the upper end of the pivoted rod which comes in contact with the upper, jointed end of the exhaust valve rod and turns it to one side. In this position the exhaust valve rod, on its upward stroke, misses the exhaust valve spindle, passing to one side of it, and the exhaust valve consequently is not opened, the waste gases cannot escape from the cylinder, and a new charge of explosive mixture can obviously not enter. No impulse can, therefore, take place in the cylinder until the speed has become slower and the exhaust valve rod has been allowed by the governing gear to resume its original position where it can strike the exhaust valve spindle and open the valve.

The pipe R, Figs. 82 and 83, is one of the water circulating pipes delivering cooling water from a small pump, marked 2, to the jacket Q around the cylinder, another pipe returning the water, which may be used over and over again, to a tank marked 1. Where some other source of water supply is available, the tank and pump may, of course, be dispensed with. In fact the design shown in Fig. 83 is now but little used. With the pump and tank attachment, however,





FIGS. 84 AND 85.—PERSPECTIVE VIEW AND ELEVATION OF DOUBLE-CYLINDER DAIMLER MOTOR.

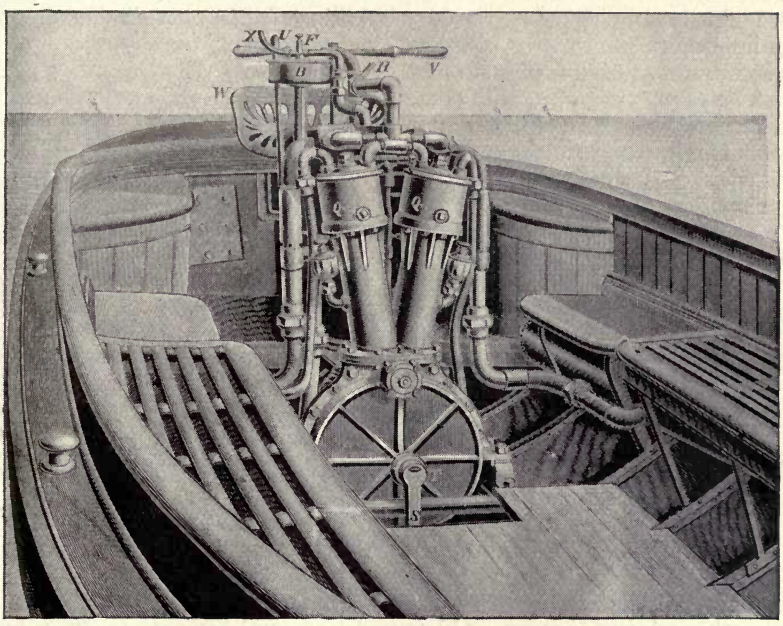


FIG. 86.—A DAIMLER MOTOR LAUNCH.

the motor is entirely self-contained and can be used anywhere, without dependence upon either gas or water mains. The tank I, Fig. 82, serves for gasoline storage and can be conveniently located, outside of the building if desirable.

A float index E on the carburetor A, indicates the level of the gasoline within. When the carburetor is completely charged, the supply will last about five hours. Where the reserve tank I is applicable it will be necessary to charge the outfit only once a day for a running time of ten hours. When gas is available the carburetor and reserve tank naturally are done away with, and the engine assumes a somewhat simpler appearance, as shown, for example, in the illustration of the double-cylinder motor. The single cylinder design is followed for sizes up to one horse-power; beyond that, two and four cylinders are employed. In the four-cylinder engines, and also in some of the two-cylinder engines as built in Germany, the cam-groove exhaust valve gear as here described is not used, but in its place a separate cam shaft, driven by gearing from the main shaft is employed. The general features of design and the manner of working are, however, exactly the same. When used for boat propulsion, the motor is generally completely boxed in so as to protect it against the weather, and is fitted with a suitable reversing gear.

Being of German origin, the engines having first been built by the Daimler Motoren Gesellschaft, of Cannstatt, which is still making them, it is only natural that in Germany and in Europe generally we should find the motor applied most extensively and to the widest variety of uses. At Stuttgart, for example, it is in successful operation in propelling a street car. It has also been applied on some of the German railroads to driving small inspection cars, similar to the familiar hand cars, and has similarly found favor for the propulsion of road carriages, quadricycles and even bicycles, not to mention the large number of pleasure boats which are equipped with it. The English firm of Sims & Company, of London, are actively prosecuting the introduction of the motor into British territory.

Before finally leaving the Daimler motor a little more information concerning the carburetor used may not be amiss. A sectional view of it, with some of its accessories is, therefore, given in Fig. 89. The lower part of the apparatus consists of a small tank H, containing a float B, which rests upon the gasoline. The float is provided with a central funnel which communicates with the main body of the liquid in the tank through a small opening at the bottom, so that while the liquid is maintained at a constant level in the funnel, it is practically isolated from the main body of the petroleum. The float is provided with an air tube entering the funnel, and perforated below the surface of the gasoline. This air tube slides freely in the tube F, attached to the cover of the apparatus and acting as a guide, allowing the float to rise and fall according to the supply of gasoline. Hot air is admitted to the carburetor through the pipe attached to the upper part of the apparatus, the air being heated in its passage to the carburetor by the products of combustion as already explained in describing the engine proper. The carbureted air passes through the vapor pipe in the direction indicated by the arrow, and unites with a stream of air drawn into the motor cylinder through the admission valve at G. This valve is provided with a graduated scale which facilitates the adjustment. It has also an automatically operating safety valve. The reservoir is filled through a supply pipe extending down to the bottom through the air tubes and float. The supply pipe communicates with the lamp font *p*, which furnishes the oil to the burner, by means of which the ignition tube is heated. The time required for heating the latter and starting the motor is inappreciable. The motor may be stopped temporarily by shutting off the supply of combustible gas, allowing the ignition tube burner to continue burning. For a complete stop, however, the ignition tube burner is extinguished in addition to shutting off the gas.

One of the most interesting and ingeniously designed gas engines put on the market by English makers is the Atkinson differential engine, first brought out eight or nine years ago by the British Gas Engine & Engineering Company, of London. The main object

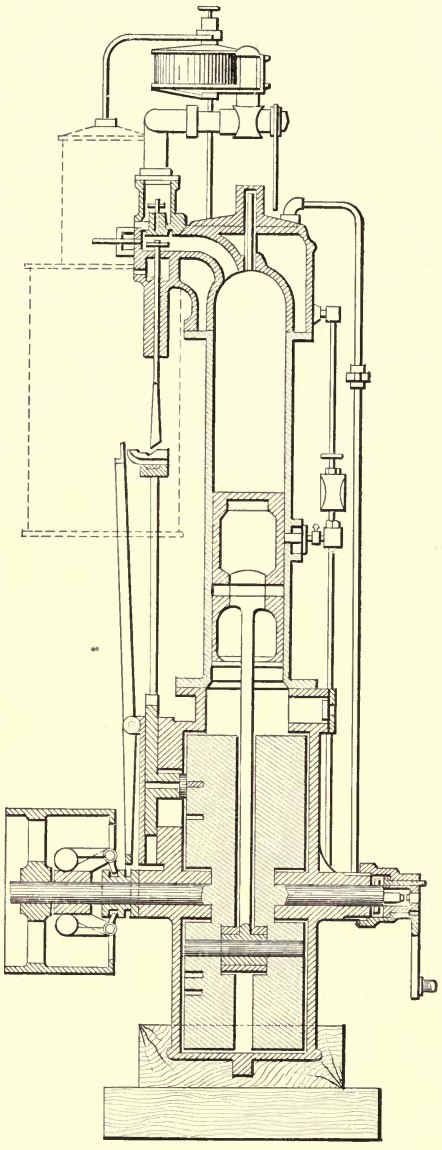


FIG. 87.—SECTION OF DAIMLER MOTOR.

sought after in this engine was to allow the exploded charge to expand much more rapidly than is usual or possible in most other gas engines, and to thus be in contact with the relatively cold cylin-

der walls for a shorter period of time. In this way, it was agreed, an important economical end is served.

The engine in its earliest form is shown diagrammatically in Figs. 91 to 94, from which the main peculiarities of its operations will be more clearly understood. The cylinder in this early design was open at each end and had two pistons connected by curved levers and short connecting rods to one crank pin. The through a port in the cylinder wall. The crank pin was, at this time, on the left, and as it proceeded upward and around to the right, the left-hand piston moved rapidly away from the other, leaving a space between them into which the gas and air mixture was drawn through a self-acting suction valve. When the crank pin had reached its highest position, as in Fig. 92, the right-hand piston traveled past and closed the openings to

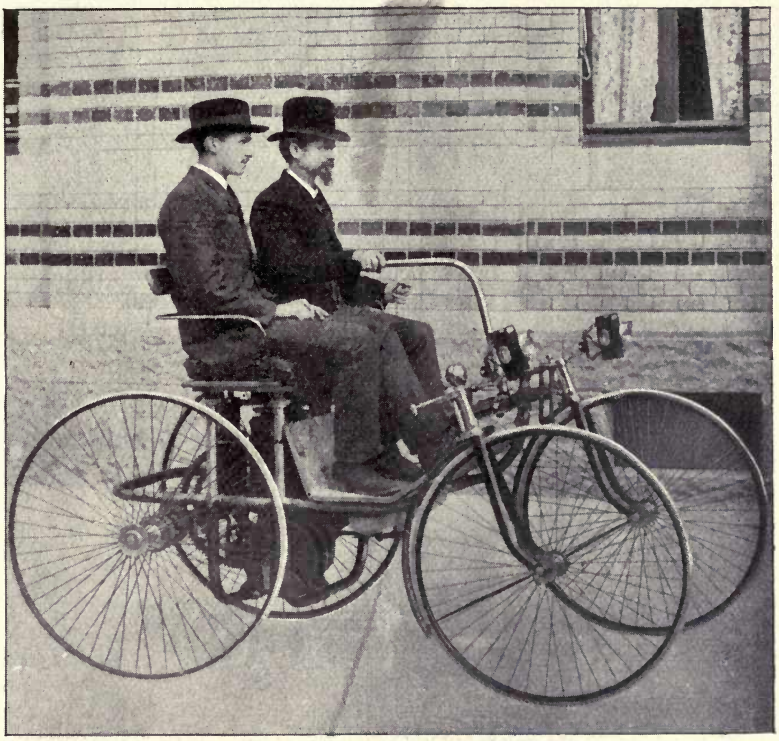


FIG. 88.—QUADRICYCLE PROPELLED BY A DAIMLER MOTOR.

pistons both traveled in the same direction but at very different speeds. When at the outer end of their stroke, they remained almost at rest for nearly half a revolution of the crank pin, but when at the inner end of the stroke they traveled rapidly. When the pistons had completed a stroke to the right, as in Fig. 91, they almost touched each other, and had driven out the products of combustion of the previous working stroke the suction and exhaust valves, and during the next quarter turn the pistons again approached each other, compressing the explosive charge between them, the crank pin by that time being over at the right-hand side, as in Fig. 93. At the moment of greatest compression, the left-hand piston passed an opening to an ignition tube which produced explosion of the charge, and an immediate, rapid stroke was made by the right-hand

piston and was completed by the time the crank pin arrived at the lower quarter, as in Fig. 94. The exhaust port was then opened by the continued travel of the piston, and the contents of the cylinder were driven out through the self-acting exhaust valve by the left-hand piston which assumed the position shown in Fig. 91, the whole cycle being completed in one revolution of the crank-shaft.

The space between the pistons into which the ignited charge expanded was nearly double the space into which the charge was first drawn previous to explosion; consequently, the expansion amounted to nearly twice the original volume, and the terminal pressure at which the gases were expelled from the cylinder becomes very low. It will also be observed that the total expansion to twice the original volume took place in a quarter revolution of the crank-shaft as compared with other gas engines and this expansion to double the original volume was accomplished in one-fourth of the time taken for the same degree of expansion in other engines, assuming the engine to run at the same speed. The economy to be gained from the extra expansion is obvious, while the saving due to the rapid motion of the piston is also beyond question, having been conclusively demonstrated experimentally by a French authority, Professor Witz, a number of years ago.

Without going in detail into the experiments made by him, it may not

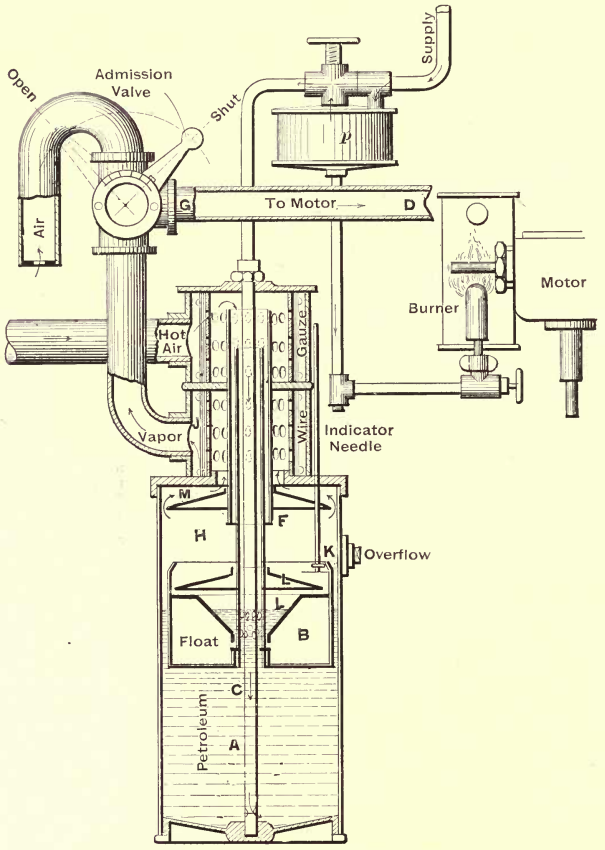


FIG. 89.—SECTIONAL VIEW OF THE CARBURETOR USED WITH THE DAIMLER MOTOR.

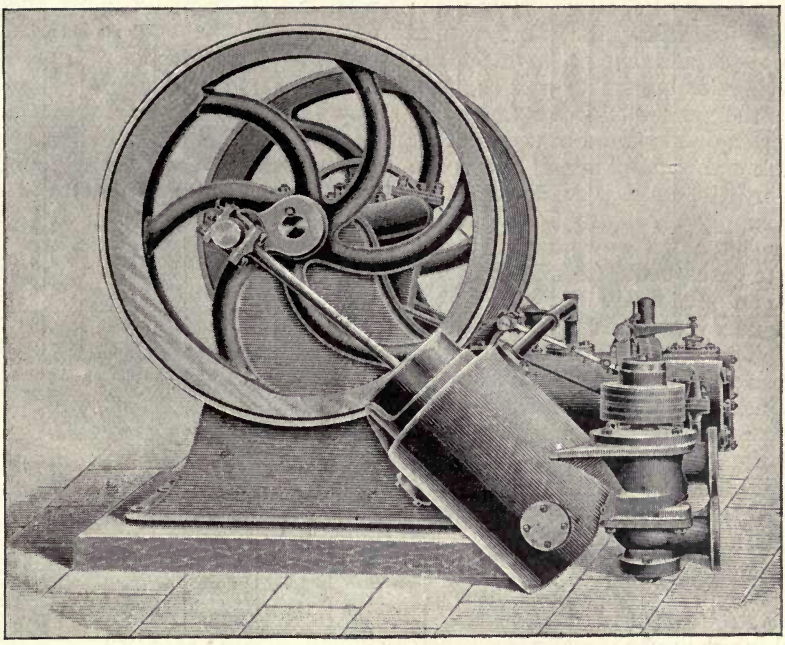


FIG. 90.--ATKINSON'S MODERN GAS ENGINE AND AIR COMPRESSOR COMBINED.

be uninteresting to here briefly state that in one series of experiments he used a mixture of one volume of illuminating gas and 6.33 volumes of air—a not unusual proportion for gas engines. This mixture was drawn into an experimental cylinder and exploded, the piston being allowed to travel at the rate of 1.7 meters per second, corresponding to an ordinary piston speed in a medium-sized gas engine. The actual amount of work done was estimated from a diagram obtained from the cylinder. He then increased the speed of the piston, and found that by allowing the piston to move at the rate of 4.3 meters per second, or 2.54 times as fast as before, the same amount of gas did 2.9 times as much actual work. This large increase is chiefly due to the fact that the heat of combustion of the gaseous mixture is, at the higher speed, not allowed to continue so long in contact with the walls of the cylinder which are kept cool by the customary water jacket. It has been held that more than one-half of the total heat in the gas, even if thoroughly consumed, is lost by transmission to the water. If then the work is done in one-fourth of the time, as in the Atkinson engine, three-fourths of this serious loss must be saved, since the transmission of heat through metallic substances is directly proportionate to the length of time that the differences of temperature exist; hence, the great increase of power shown by Professor Witz's experiments.

The engine in its early form was extremely simple. There were no slide-valves, nor were there any complicated substitutes, the working charge being efficiently controlled by the pistons passing the ports to the two self-acting valves and the port to the ignition tube. There were also neither cams nor eccentrics. In the course of the last few years, however, the design of the engine has undergone some changes, so that at the present time its appearance is like that shown on this page.

The "Utilité" gas engine, built by the same firm, was not designed as a rival to their standard engine, but

simply as an alternative motor for obtaining practically the same results and, to a certain extent, to meet the varied views of buyers of gas engines. Perhaps the most distinctive feature of this later engine is found in the fact that the crank end is cased in and the space thus afforded is used as an air chamber whose supply serves to flush out the cylinder after each working stroke, the waste gases being allowed to escape through an opening in the side of the cylinder uncovered by the piston in its travel. There is thus no exhaust valve of the usual kind. After the flushing of the cylinder has taken place, a small charging pump delivers into the firing end of the cylinder a rich mixture of fresh gas and air, the air proportion, however, being insufficient to permit explosion until it has been further added to.

The piston, after having made a working stroke, returns and is allowed to expel through the exhaust opening some of the cylinder contents which, at the piston end of the cylinder, are made up of waste products of combustion or, perhaps, simply air. At about half the return stroke, however, the piston closes the exhaust opening or port, and what then remains in the cylinder is air and gaseous mixture in more or less definitely separate layers, the gas mixture being in the firing end of the cylinder, and the air alone, in the piston end. As compression takes place, the air and gas and air mixture become more intimately mixed and by the time the cylinder contents are fully compressed they are in a proper condition for ignition which then takes place ; a working stroke is made in this manner once for every revolution of the crank-shaft. A small valve, in addition to the exhaust opening in the cylinder wall, controlled by an eccentric, allows a portion of the air to be removed from the cylinder before the compression stroke is completed, so as to leave only about one-half the original cylinder contents shut up, which, after compression and ignition, is allowed to expand to double its original volume. As a result, the diagram from the engine is practically the same as the diagram from the regular Atkinson engine, and the economy of the two is claimed to be practically the same. It is further claimed for the "Utilité" engines that they combine great lightness with rigidity and that they can be run at very high speeds without heavy foundations and without causing any trouble from excessive vibration. Speeds as high as 600 revolutions per minute are claimed to have been maintained with good results.

One of the later types of vertical gas

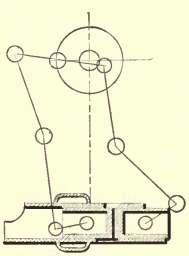


FIG. 91.

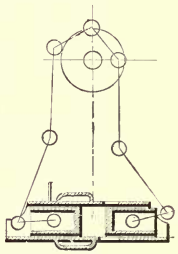


FIG. 92.

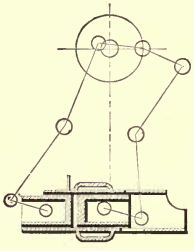


FIG. 93.

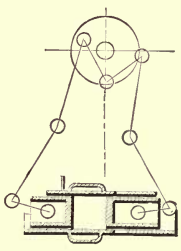


FIG. 94.

DIAGRAMS OF THE ATKINSON DIFFERENTIAL ENGINE.

engines is that made by the Hartig Standard Gas Engine Company, of Brooklyn, N. Y., both single and double fly-wheel designs being shown in Figs. 95 and 96. There are, in all, four valves in this engine,—a governor valve, automatically controlling the gas supply according to the amount of power required, a lighting valve, a gas and air admission valve, and an exhaust valve. The governor valve is in the main gas supply pipe and is worked by the vertical rod shown at the extreme left of Fig. 95. The governor itself is of the shaft type, the centrifugal force of the two weights being restrained by springs attached to the weight arms and to the

weights in the manner indicated. With increase in speed above the normal, the weights move outward, and revolve a cam, mounted on the crank-shaft and provided with a helical groove and pin arrangement which causes the cam to slide in and out along the line of the shaft. When moved inward, that is, a decrease in speed. With the lower speed the governor weights return to their original position, the cams are thrown out of contact, and the gas supply valve is again opened.

The exhaust valve is worked by the rod shown furthest to the right in the engraving, and receives motion from the

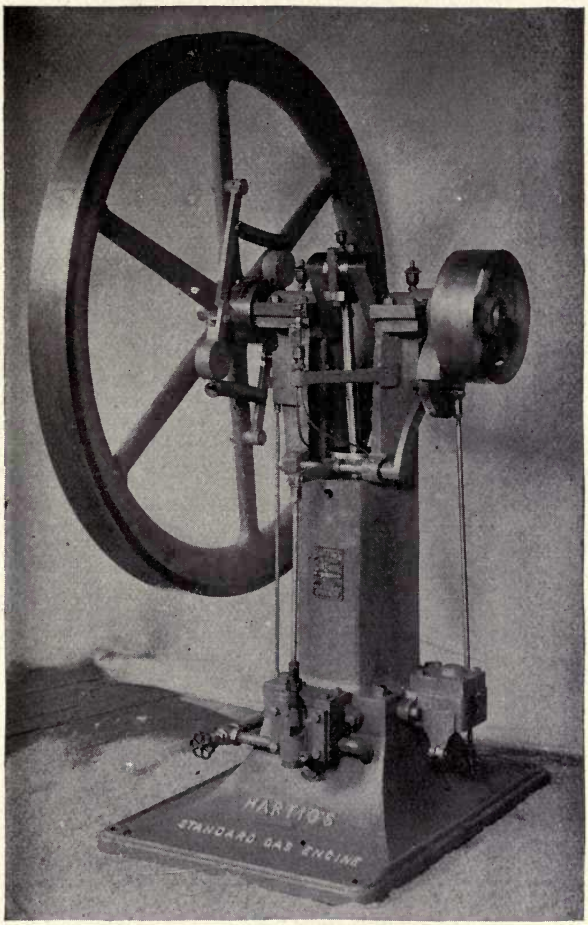


FIG. 95.—THE HARTIG ENGINE, BUILT BY THE HARTIG STANDARD GAS ENGINE COMPANY, BROOKLYN, N. Y.

from left to right in the engraving, the cam comes in contact with another and smaller cam, directly connected with the main gas valve rod, and causes the valve to close more or less, thus shutting off the gas supply or simply reducing its volume, and consequently bringing about crank through the intervention of two gear wheels, one of which has twice the diameter of the other. The valve is thus opened once in every two revolutions, the engine working on the Otto cycle. The valve rod connects with a valve lifting arm pivoted at one end,

and, in its upward motion striking the valve spindle from below and lifting the valve from its seat to which, ordinarily, it is held by a spring. The igniting valve at the front of the engine is operated by a rod connected with a rock shaft, mounted on the engine frame as clearly shown, and receiving motion from the crank shaft through a rocker arm and cam gearing. The igniting gas jet burns at the side of this valve and, at the moment of valve opening, communicates with the explosive mixture in the cylinder and fires it. The gas and air admission valve, located almost directly behind the igniting valve, is not worked by any rod or gearing, but opens under the influence of the partial vacuum formed in the engine cylinder during the suction stroke of the piston, and closes of its own accord during the compression period, remaining also closed, for obvious reasons, during the working and exhaust strokes. The valves all are of the lift type, insuring lightness and freedom from sticking and clogging. The engine is made in sizes of from one to eight horse-power, though a small half horse-power pump and engine combination is also turned out.

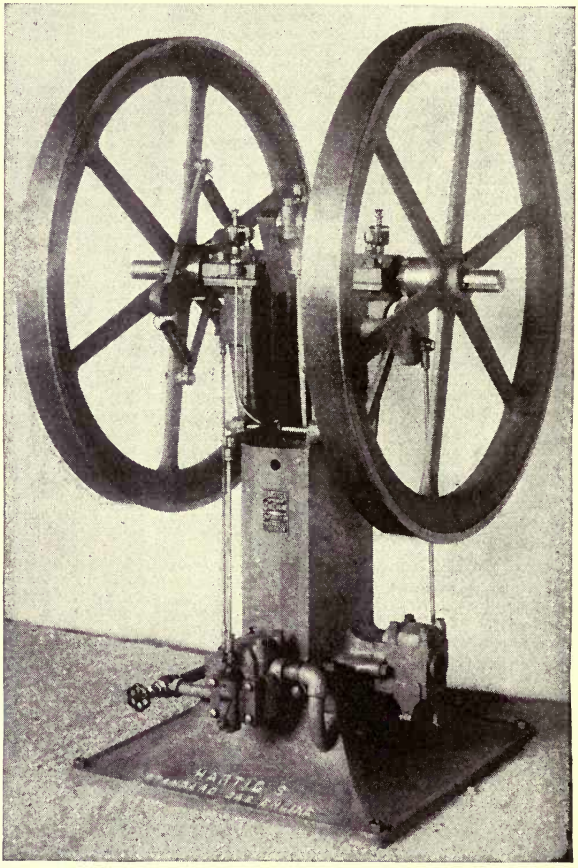


FIG. 96.—HARTIG DOUBLE FLY-WHEEL ENGINE.

Experience with this engine has shown that it is well adapted to the driving of electric light dynamos, and it is for this work that its builders make one of their strongest claims, being specially pre-

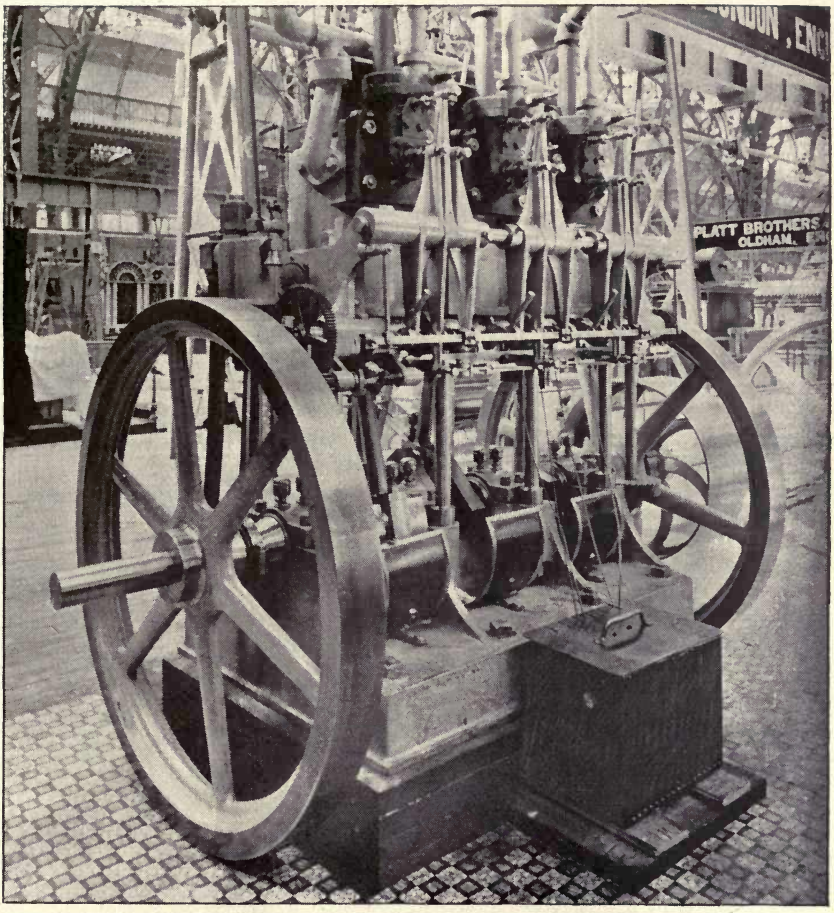


FIG. 97.—THREE CYLINDER "TRUSTY" OIL ENGINE AT THE WORLD'S FAIR.

pared to furnish gas driven, isolated electric light plant outfits.

A petroleum engine in which the now so widely used Otto cycle is not followed is that built by Messrs. Penney & Co., of Lincoln, England, and known as the Weatherhogg engine. In this a practical application is made of the six-stroke cycle, already referred to in one of the preceding papers, a scavenger charge of air being taken into and discharged from the cylinder during the interval between exhaust of the products of combustion and the admission of the working charge.

The oil is injected into a vaporizer by a pump, which acts only when the speed of the engine is normal or less, being operated by a hit-and-miss device controlled by the governor. The oil is delivered into a coil heated by a blowpipe flame, and is there vaporized under pressure. The flame is produced from a spray of petroleum, and is fed by compressed air from a pump, which can be worked by hand at starting.

When starting the engine, a handle is fixed to the crank which works the pump, and it is rotated by hand for a few minutes, until the coil is hot. The oil is then injected and the vapor is allowed to accumulate until it attains a considerable pressure, which is maintained during working. It is claimed

that better results are obtained by this pressure, and that it enables crude petroleum to be used if required. The pressure can be regulated by adjusting a throttling device at the outlet of the vaporizer. Between the vaporizer and the cylinder is the air admission valve, contained in a box in which mixture of the charges take place, ignition being effected by a heated tube. In some cases a part of the air is taken from a box in which the crank and connecting-rod are inclosed, and in this way any leakage past the piston is caught and prevented from escaping into the engine room.

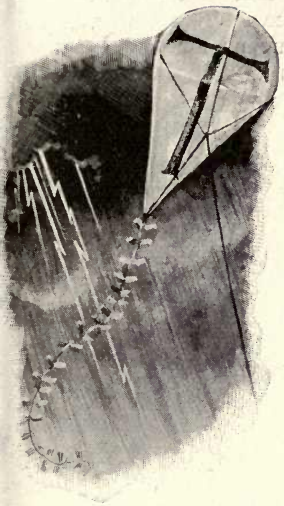
In connection with the "Trusty" double-cylinder oil engine shown in the June number, it is of interest to direct attention to a vertical, three-cylinder oil engine built by the same firm, Messrs. Weyman & Hitchcock, of Guildford, England, and shown at the World's Fair at Chicago. The principle of operation is essentially the same as that of the engine already described. The three cylinders are connected to a three-throw crank shaft, with the cranks set at angles of 120 degrees, so that the work of the cylinders is well distributed throughout the period of each revolution. The valve gear is worked from a cam shaft driven by worm gearing, but each cylinder has its separate cams so that any one of them may be cut out at will.

(*To be continued.*)

MODERN GAS AND OIL ENGINES

By Albert Spies, Mem. Am. Soc. M. E.

Seventh Paper.



THE methods of igniting the working charges in gas and oil engines are details of design to which considerable study has been given without, however, having brought about anything like uniformity of practice. No one particular device, as was to be expected, has been centered upon as the best or most desirable one, and recurrence to the descriptions of engines already given in the preceding papers will show that electric ignition, flame ignition and ignition by incandescence all have found a share of favor in the eyes of gas engine builders. Electric ignition has been practiced either by the spark method, as in the early Lenoir engine, in which, at the proper times, an electric spark was made to pass between two electrodes within the cylinder, or by the incandescent wire method, in which an electric current was applied directly to heat a thin platinum wire. This latter method would appear to have been used only in an experimental way. Still another electric arrangement has been suggested a number of times, by which an electric arc was to be maintained in the cylinder of the engine, between two heavy platinum points, but this device, so far as can be found, simply figured in patent specifications, and never came into actual use.

The flame method is currently employed in many good engines of the present day, and was put into its first practical shape more than fifty years ago, since which time it has undergone a variety of modifications. With the early non-compression engines, in which the pressure in the cylinder before explosion of the charge was the same as, or even less than, the pressure of the atmosphere, flame ignition was a comparatively simple thing, and it was easy enough to transfer a flame from the outer air into the interior of the cylinder with little, if any, trouble from extinction. In the early flame-ignition experiments the very simple expedient was adopted of providing a hole in the cylinder wall, which hole was uncovered by the piston after a portion of the stroke had been passed over, and the flame was sucked through it into the cylinder. The hole was either so small that no appreciable loss of pressure occurred upon explosion of the charge, or it was covered by a small valve which closed automatically as soon as the pressure in the cylinder rose. When the gases to which the flame was to be communicated, however, were under a pressure of some magnitude, as is the case in nearly all the gas engines of the present time, the difficulties of the ignition problem were at once increased. The method just referred to, and not inaptly termed the "touch-hole" method, obviously became inapplicable, and special valve devices had to be designed to meet the new conditions, a good example of one of them being that of the earlier Otto engine, as illustrated in the first paper of this series.

Ignition of explosive gas and air mixtures by contact with more or less highly heated metallic surfaces, or the hot-tube method, as it is now generally termed, was suggested independently by several investigators a number of years ago. The general scheme pro-

posed was to ignite the gas and air charge by passing it through a metal tube heated to redness by a flame outside of it, and this method is in successful use to-day in a large number of engines. Wrought iron is generally employed for the tubes, though in a few engines platinum has been pressed into service, its higher cost being counterbalanced, in a measure, by its greater durability. A difficulty with the iron

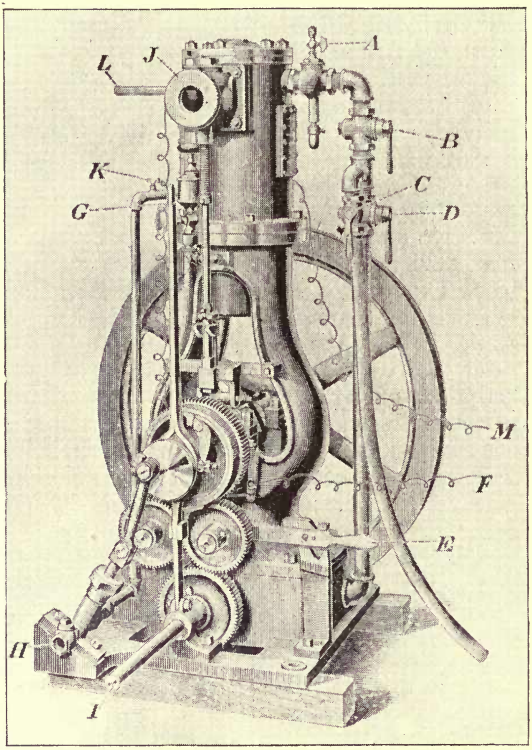


FIG. 98.—THE PACIFIC ENGINE—MARINE TYPE.

tubes is found in their rapid oxidation and furring, necessitating their more or less frequent renewal, but with their cheapness and the ease with which an old and worn-out one may be replaced by a new one, this objection is not so serious as might be supposed. In some engines the tubes are so screwed into the cylinders as to be constantly in communication with them, while in others valves are arranged which admit the compressed air and gas charge to the tubes at the proper moment. The flame method and the hot-tube method just mentioned are the ones which seem to have secured the greater measure of popularity, being claimed, by their advocates, to be more certain in action and cheaper and simpler in arrangement than the electric devices. The latter, however, are by no means allowed to rest under any such imputations of comparative inefficiency. A number of engine builders have devoted much energy to their development, and as a result this type of ignition device is now used with much satisfaction in some of the best engines on the market. A flexible electrode arrangement, which is employed in several of these devices, affording absolute certainty of contact in completing the electric battery circuit, is one of the most important im-

provements that has been made in connection with them, and to it is mainly due their present satisfactory action.

One of the forms of gas and oil engines, in which this arrangement is in

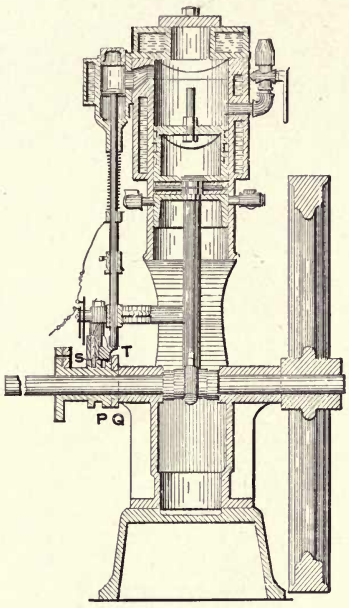


FIG. 99.—SECTION OF PACIFIC ENGINE.

use, and which has attained much popularity, especially for boat propulsion, is the Pacific engine, built both by the Union Gas Engine Company, of San Francisco, Cal., and the Globe Gas Engine Company, of Philadelphia. One of the earlier designs of this engine, arranged as a launch motor, with reversing gear and circulating pump for the cylinder water jackets, is shown in Fig. 98. In this *A* represents a relief valve, through which part of the compressed vapor may be allowed to escape to facilitate starting up the engine. The throttle valve is marked *B*, while *C* and *D* are gas and air regulating cocks; *E* is the reversing lever which, by being shifted from the upper to the lower position, brings a back gear into operation and causes the propeller shaft to run in a reverse direction; *G* is a clutch lever for stopping and starting the propeller shaft. The circulating pump *H* takes water through the bottom of the boat, and discharges it into the lower part of the water jacket around the cylinder, while the overflow pipe *L* from the upper part of the jacket is led out through the side of the boat above the water line. Water from the jacket may be drained off through the cock *K*. The coupling for connecting the engine with the propeller shaft is placed at the end of the secondary shaft *I*. The exhaust valve is marked *J*. The engine works according to the Otto cycle, and the charge, as previously intimated, is fired by an electric spark, *F* and *M* being the wires from the battery, the former connecting with an interrupting device, so that a spark is produced only at the beginning of every second down stroke of the piston. It will be understood that, like in the several other launch outfits,

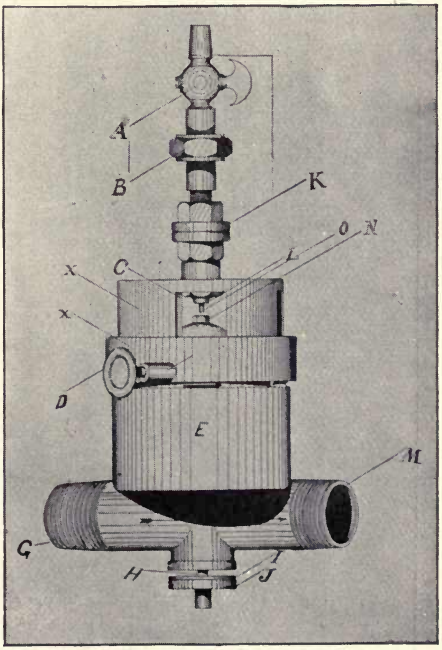


FIG. 100.—THE VAPORIZER.

described in some of the preceding papers, the engine itself is never reversed, but runs continuously in one direction, and the direction of motion of the propeller shaft and the secondary engine

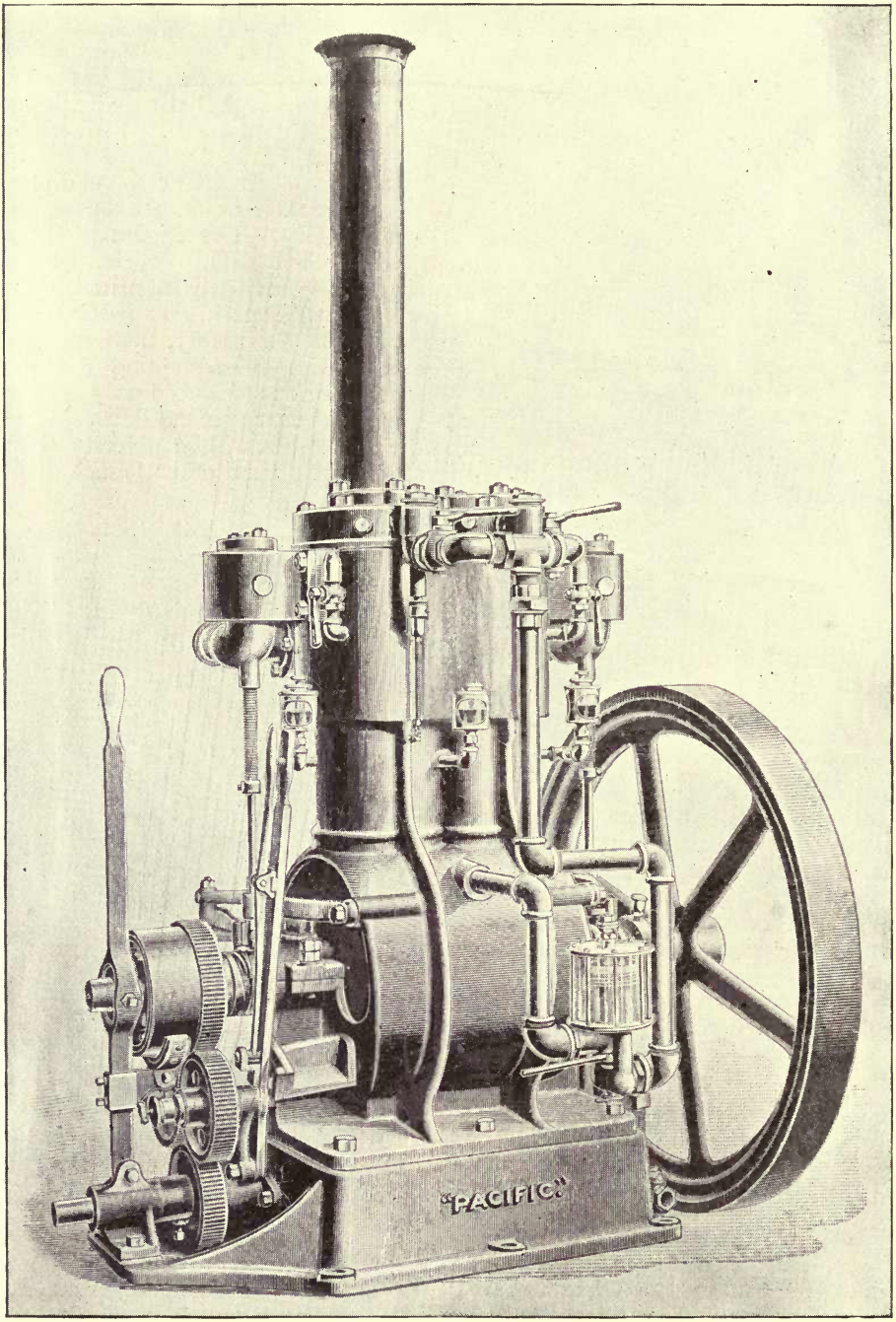


FIG. 101. - A DOUBLE-CYLINDER PACIFIC ENGINE.

shaft alone is changed, when desired, by the lever arrangement already mentioned.

The valve gearing of the engine, which is one of its special features, and entirely unlike that of any other engine in the market, is illustrated more clearly in the sectional view, Fig. 99. It will be noticed that on the crank shaft is a cam, *P*, having two grooves which run parallel part of the way around, and then intersect each other. A segment-shaped finger, *S*, rests in one of these grooves, and as the engine shaft revolves the finger is guided through the intersection from one groove to the other, and carries a swinging arm, *T*, under the exhaust valve stem once in every two revolutions. The cam *Q* at those periods lifts the arm *T*, and with it the exhaust valve rod, opening the valve and permitting the escape of the waste gases from the cylinder. The governor acts directly on the exhaust valve rod, holding it up, with the valve open, whenever the speed of the engine rises above the normal. The effect of this, to begin with, is that neither back pressure nor partial vacuum are created in the cylinder when running without working explosions, air from without being alternately drawn into the cylinder and expelled from it through the exhaust pipe. Admission of fresh gas and air mixture into the cylinder is, at such times, prevented simply by the fact that the exhaust passages are very large as compared with the gas and air inlet, and the exhaust valve, as stated, is held wide open, and there is thus less resistance to the flow of air through them than there is to the flow of gas and air mixture through its regular admission port and valve. The latter will, therefore, not open, and, consequently, no working charge can enter the cylinder until the governor catch on the exhaust valve rod is released by a falling-off in the engine speed and the exhaust valve is allowed to close.

The design of the engine has latterly been somewhat modified, but only in details which but slightly change its appearance, the manner of operation remaining exactly the same. A double-cylinder engine is built on essentially the same lines as the one just described, and is shown in Fig. 101. This illustration also shows the improved form of vaporizer with which the engine is fitted when using gasoline, and which takes the place of the various forms of carburettors employed in connection with most other engines. The vaporizer is shown attached to the lower right hand part of the engine, at the side of the base near the fly-wheel, a detail view being given in Fig. 100. It consists of

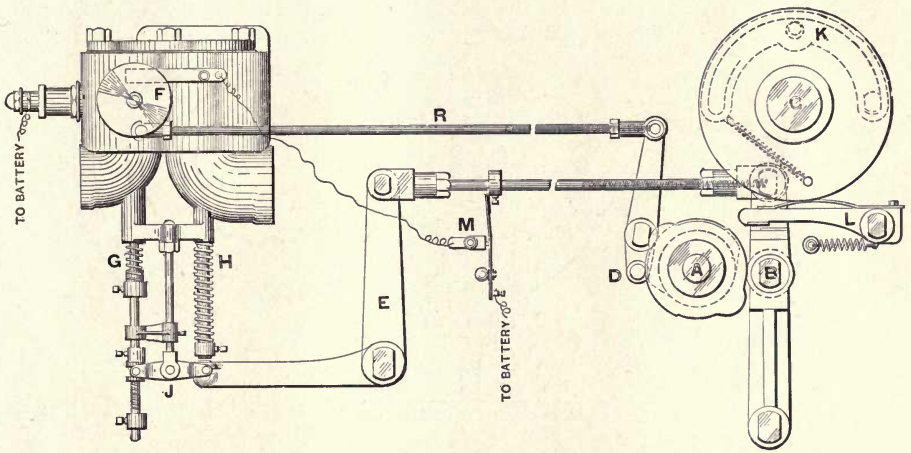


FIG. 102.—VALVE GEAR OF THE UNION ENGINE.

either a glass or metal body *E*, glass being used in the one shown attached to the engine, and inside of this is a ball-shaped valve, *N*, seated on the end of a tube connected with the air inlet pipe *G*. Connection from the vaporizer to the engine cylinders is made at *M*. A casing around the exhaust pipe of the engine affords an annular space through which the air is drawn on its way to the vaporizer inlet *G*, and is heated by contact with the hot exhaust pipe. As the air enters the vaporizer body, it lifts the ball valve *N*, and the latter strikes against the spindle *O* of the gasoline valve, raising it and permitting a small quantity of gasoline to flow into the vaporizer through the cock *A*, from a conveniently placed tank at a higher level. The gasoline so admitted is at once turned into vapor by the heated air and is drawn off on its way to the engine through the connection *M*.

The lower end of the valve *N* is shown at *H* where a leather washer, *I*, is provided on a collar, *J*, the latter preventing the valve from lifting too high. The upper part *X X* of the vaporizer proper is arranged so that it may be revolved by loosening the screw *D*, enabling the attendant to observe the flow of gasoline through the opening, *C*, if desired, when starting the engine. The gasoline and air inlet valves *O* and *N*, of course, open only during the suction strokes of the pistons, remaining shut during the remainder of the working cycles. In actual practice this vaporizer has been found to perform admirably, and some preliminary trials made even with ordinary oils have been found to give promising results. The vaporizer being directly attached to the engine, and not a separate addition like the several currently used carburettors, makes the whole outfit comparatively simple and self-contained.

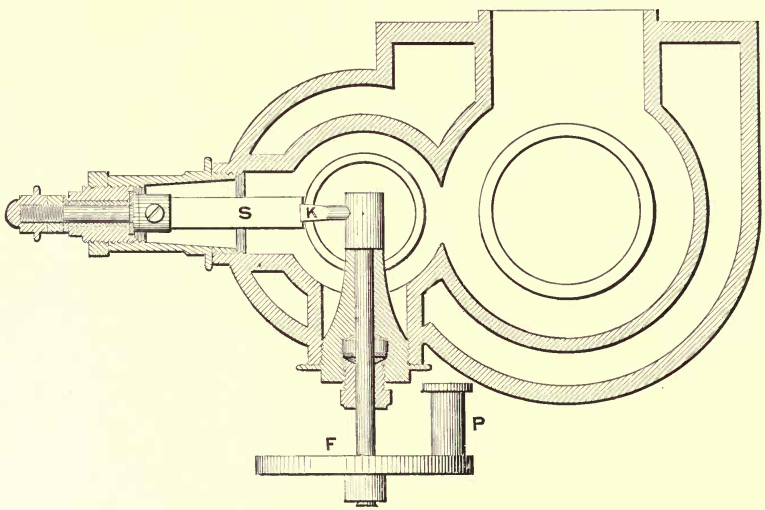


FIG. 103.—VERTICAL SECTION THROUGH VALVE CHAMBERS OF UNION ENGINE.

The stationary Pacific engine is, in all essential details, the same as the marine type except that the reversing and clutch gears are omitted.

Another engine, of the horizontal type, however, made by the same builders, and known as the Union engine, is shown in Fig. 104. Details of the valve gear and igniting device are shown in Figs. 102 and 103, the former representing an arrangement slightly different in appearance from that seen in the general view of the engine in Fig. 104, but exactly the same so far as the manner of operation is concerned. Motion from the crank shaft *C* of the

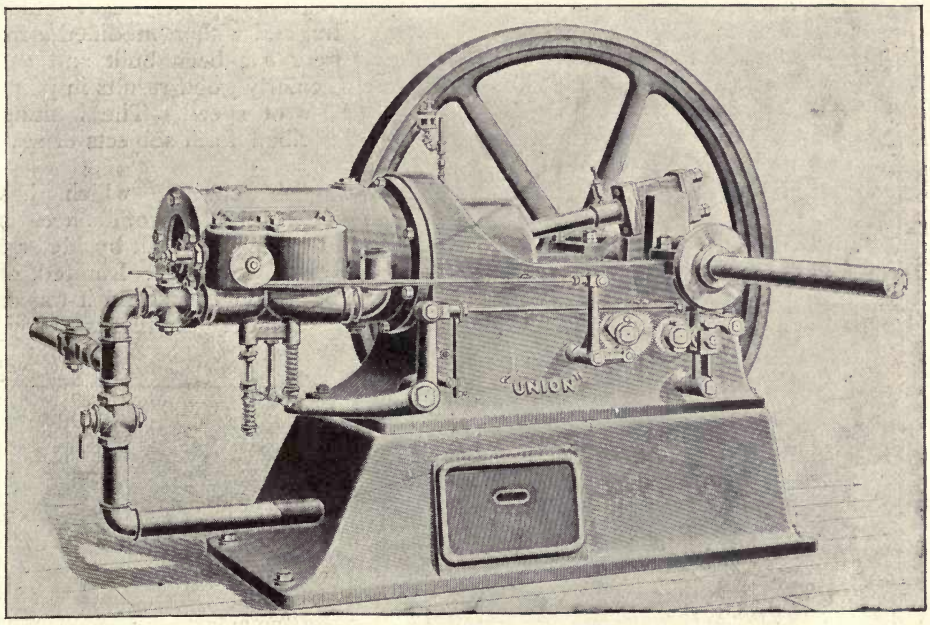


FIG. 104.—THE UNION ENGINE.

engine is reduced and transmitted to the cam shaft *A* through a series of intervening gear wheels not shown in the illustration, and the several cams on this shaft *A* operate on the cam rollers *B* and *D*, the former being on a rocker arm which works both the inlet and exhaust valves at the same time through a bell crank, *E*, while the latter is on another rocker arm controlling an electrode disc, *F*. The inlet and exhaust valves are designated by the letters *G* and *H*, respectively, and it will be easily seen that when one of these valves is closed, the other is opened, and vice versa, a small rocking beam, *J*, being interposed for this purpose.

Mounted on the engine crank shaft is also the governor with its restraining spring and weight, *K*, which latter, under the influence of excessive speed, moves outwards and, in the course of its revolution, depresses the catch lever *L*. The latter when so depressed hooks on to the upper end of the rocker arm *B* when the latter reaches its extreme right hand position, and keeps it there, with the inlet valve *G* closed and the exhaust valve *H* wide open, until the speed becomes slower and the governor weight again moves inward and no longer presses down the lever *L*.

As in the case of the Pacific engine, previously described, the exhaust valve, in virtue of this arrangement, is held open constantly while the idle strokes of the piston are being made, air being freely drawn into and expelled from the engine cylinder through the exhaust pipe during this period, so that there is no possibility of a partial vacuum being formed in the cylinder, or of back pressure being created.

The current interrupter for the electric igniting device is shown at *M*, and requires no special explanation as its manner of working is quite clear from the illustration. There is, it will be noticed, a flexible contact strip carried by a collar on the rod operating the bell crank *E*, and this strip, in moving back and forth with the rod in question, makes and breaks the electric contact at *M* at the proper periods which are determined both by the governor and by the nature of the reduc-

ing gearing between the crank shaft *C* and the cam shaft *A*.

A vertical section through the exhaust and inlet valve chambers, showing also the nature of the igniting electrode arrangement which is somewhat different from that used in the Pacific engine, is given in Fig. 103. The rod *R*, in Fig. 102, connects by means of the pin *P*, with the electrode disc *F*, seen in both views, and gives it an oscillating motion which, of course, is imparted also to the electrode *K* carried on the end of the electrode disc spindle. This electrode *K*, as will be at once understood, is thus made to alternately strike and clear the flexible electrode *S*, which is connected with one of the battery wires, and when contact is thus made and broken at this point, contact also being made at the interrupter *M*, in Fig. 102, a spark is produced which fires the explosive charge in the inlet valve chamber and cylinder. A four-cylinder engine of this type, with the cylinders placed opposite one another in two pairs, and with a modified form of valve gear has been built and has given particularly good results in point of steadiness of speed. The igniting devices described form subjects of several patents.

An English engine, which has achieved considerable prominence, is the Stockport engine, built by Messrs. J. E. H. Andrew & Co., Limited, of Stockport. In its early form it was of the double-end design—that is to say, there were two horizontal cylinders placed opposite each other, one being the motor cylinder proper, and the other, the compressor cylinder, and the crank was placed midway between the two. A number of modifications have, however, of recent years, been instituted in the design, so that, in one of its latest shapes, the engine is substantially like that shown in Fig. 105. In this, it will be observed, there is no separate compressor cylinder, and the

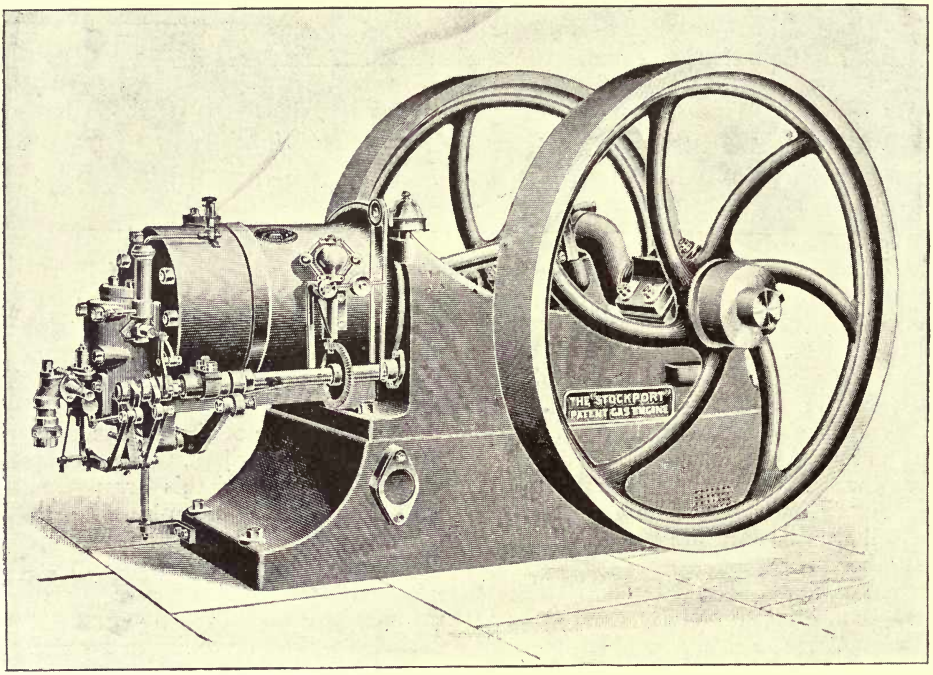


FIG. 105.—THE STOCKPORT ENGINE, BUILT BY MESSRS. J. E. H. ANDREW & CO., LTD., STOCKPORT, ENG.

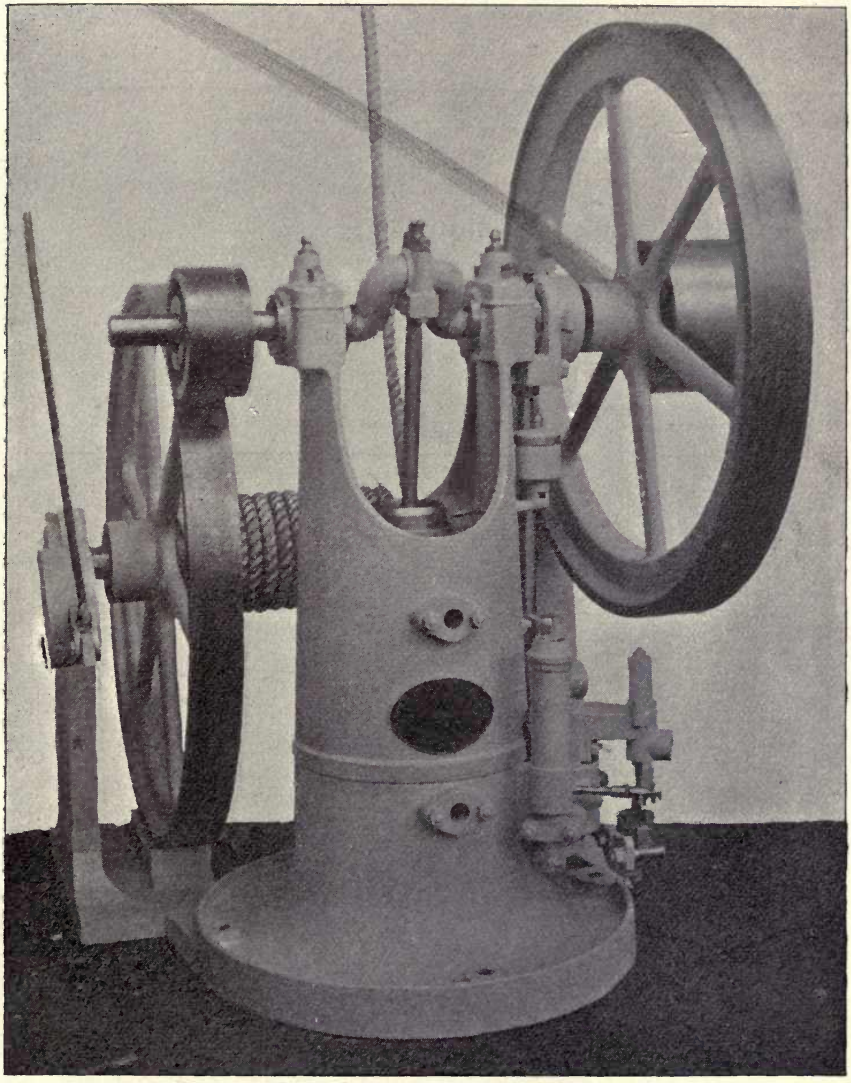


FIG. 106.—VERTICAL STOCKPORT ENGINE FOR HOISTING.

engine works according to the regular Otto cycle, with, normally, one explosion in every two revolutions. The valve gearing and governor are operated from a secondary shaft running along the side of the cylinder, and driven from the main shaft through intervening bevel gears. Firing of the working charge is accomplished by a tube igniter, and the valves all are of the poppet type. On the larger engines the type of governor shown in Fig. 105 is used, while the smaller sizes are provided with a vibrating governor shown on page 375, in which a weight, riding on a spring, is moved by a vibrating lever. So long as the engine runs at a certain speed the weight keeps in position a small hit-and-miss lever, and gas enters the cylinder of the engine. With any variation of speed above the normal, however, the posi-

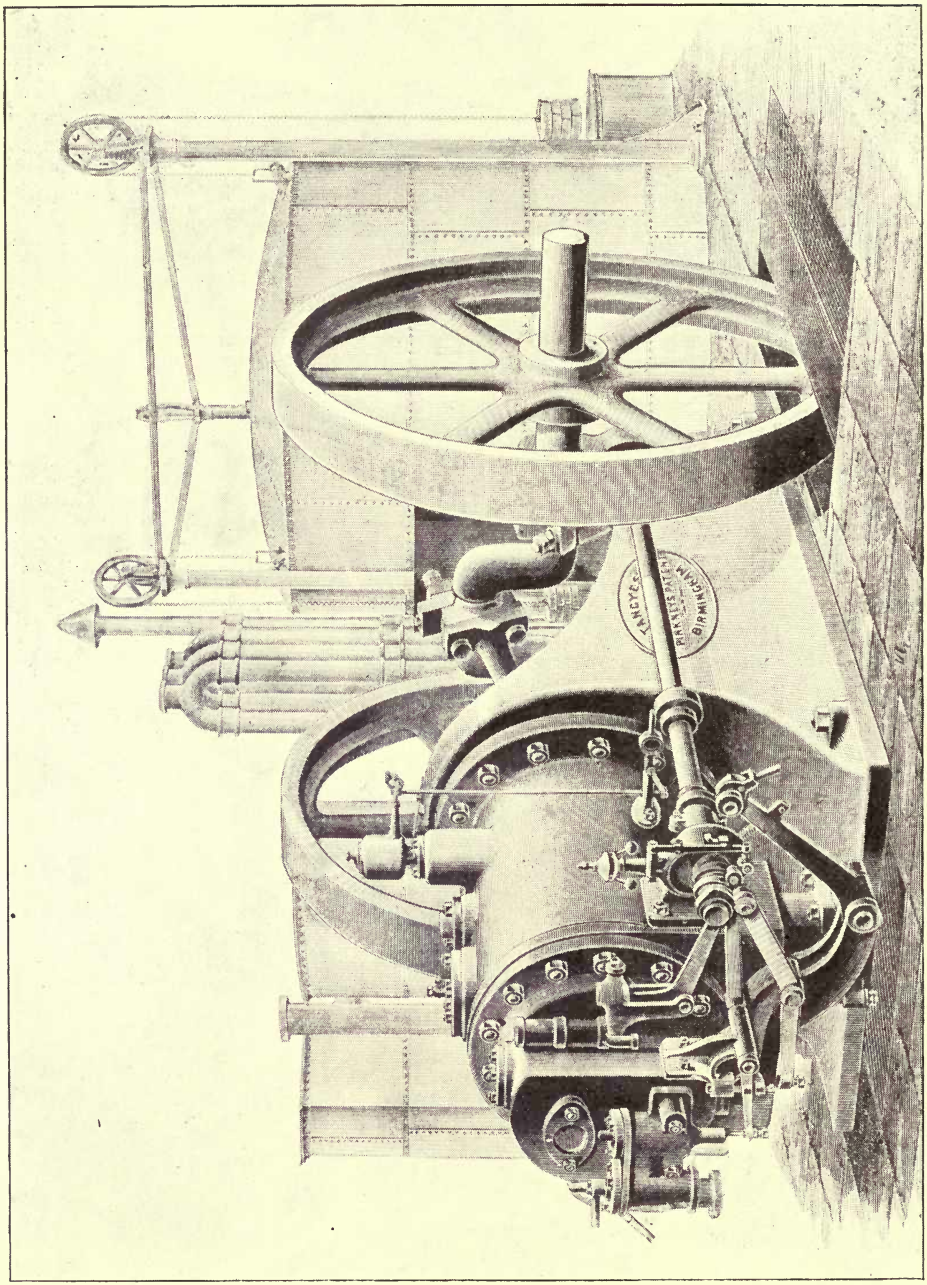


FIG. 107.—ONE HUNDRED INDICATED HORSE-POWER TANGYE ENGINE WITH GAS PRODUCING PLANT.

tion of the weight changes, moving the valve operating lever out of gear and cutting off the gas supply. For electric lighting and other work requiring very steady motion, a special governor is used for varying the explosive mixture, so that the speed may be controlled without missing explosions in the cylinder.

Messrs. Andrew & Co., who, by the way, are, next to Messrs. Crossley Bros. of Manchester, England, probably the oldest firm of gas engine builders, are the makers also of the Bisschop engine—an engine which will probably appeal only to the smaller power users, being a surviving form of the early non-compression type of motor which has been almost completely driven out of the commercial gas engine field by the developments of recent years. In this engine the principal end aimed at is to get a small, workable engine with the least possible complication, economy of gas being a secondary consideration. Instead of having a water jacket, the cylinder has cast on it a number of radiating ribs, which carry away the heat of the explosions and keep the temperature of the cylinder walls at a reasonable point. The cylinder is vertical, the piston rod and its connections extending upward, and motion from the crosshead being imparted to the crank by a vibrating lever arrangement. In order to prevent sticking of the piston in the cylinder owing to the rather high temperature which it attains, it is fitted quite loosely without rings, and the pressure from the gas explosions is so slight that the leakage past the piston is not serious. The flame ignition method is used to fire the charge, the flame being drawn into the cylinder through an opening in its walls on the already mentioned "touch-hole" principle.

In the matter of size of engines it is interesting to note that Messrs. Andrew & Co. are now building Stockport engines indicating as high as 150 horse-power in a single cylinder. One of the largest gas-driven electric light installations in England, at Morecambe, was equipped with engines by them, the plant comprising three Stockport engines of sixteen horse-power each, a Dowson gas plant, and three dynamos of 300 lights each, besides a storage battery outfit. Messrs. Tangye, Limited, of Birmingham, and Messrs. Crossley Bros., Limited, of Manchester, England, also have turned out noteworthy engines of large size, developing from

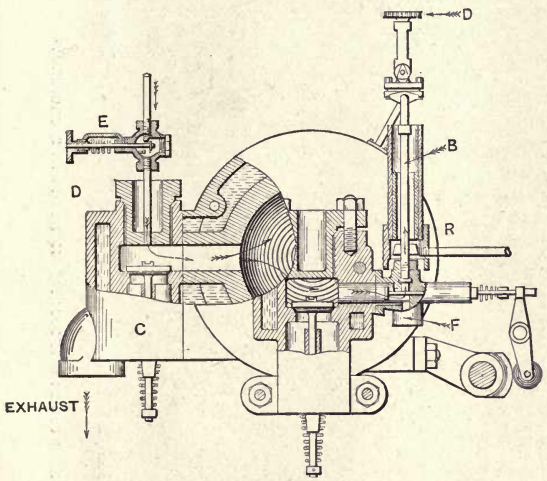


FIG. 108.—SECTION OF END OF CYLINDER OF STOCKPORT ENGINE.

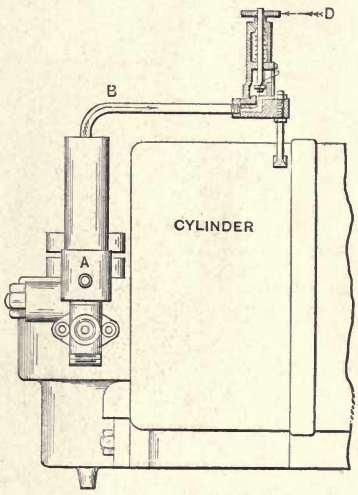


FIG. 109.—SIDE VIEW OF STOCKPORT ENGINE STARTING GEAR.

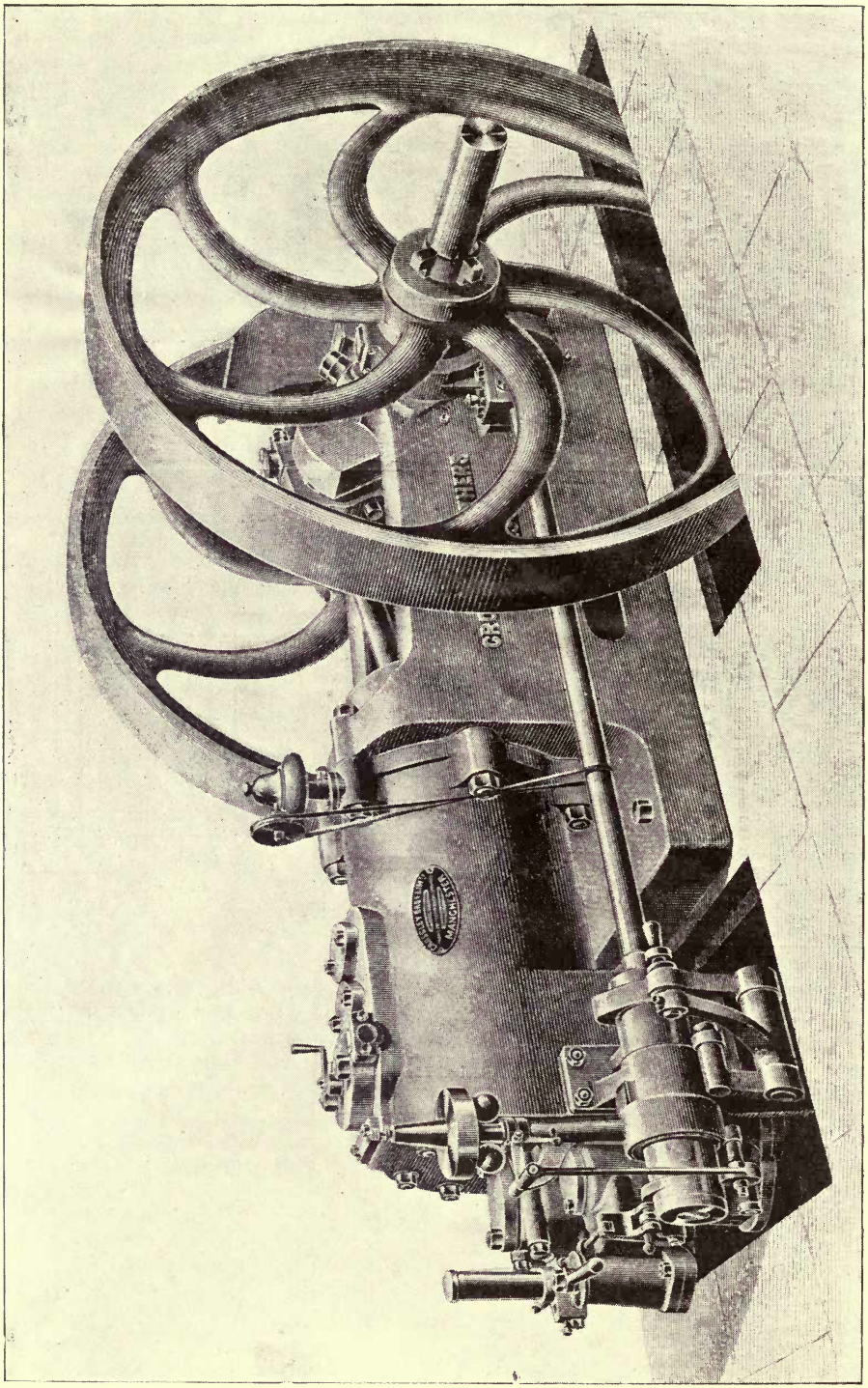


FIG. 110.—A ONE HUNDRED INDICATED HORSE-POWER CROSSLEY-OTTO ENGINE.

eighty-five to 100 actual horse-power. One of the Tangye engines, rated at 115 indicated horse-power, furnishes power for fine weaving machinery in a Belfast mill, and is stated to give eminent satisfaction, both in point of economy and steady running. The Crossley-Otto engine is, in the main, similar to the Otto engine made in the United States, and already described in the first paper of this series, so that it is not necessary to enter into its details here.

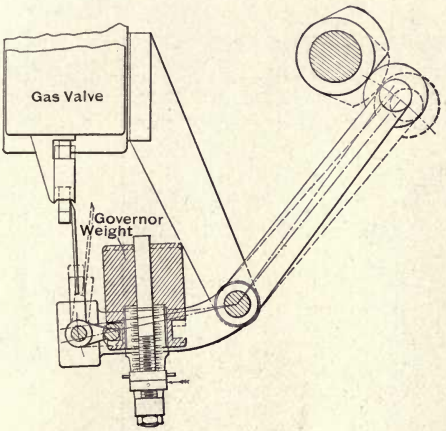


FIG. III.—VIBRATING STOCKPORT GOVERNOR.

In nearly all the larger sizes of gas engines some form of starting device is now used which dispenses with the necessity of turning the fly wheels by hand—a proceeding which is not only difficult, but, in some cases, would be quite impossible. Of these starting gears that used by Messrs. Andrew & Co. on their engines is shown in Figs. 108 and 109, the former representing a side view, and the latter a sectional view of the end of the cylinder. At *A* is a Bunsen burner for heating the ignition tube *B*. At *C* is the exhaust valve, and above it a gas admission valve *E*. Above, and at the outer end of the ignition tube *B*, is an air outlet valve, with handle *D*. At *F* is a timing valve for fixing the period at which the gaseous mixture shall be admitted to the ignition tube. When it is desired to start the engine, the gas admission valve *E*—over the exhaust valve *C*—is opened. Gas commences to flow into the cylinder, which then contains only air at atmospheric pressure. This air is allowed to escape in quantity equal to that of the gas admitted by the valve at the end of and above the horizontal part of the ignition tube *B*. As soon as sufficient gas has in this way flown into the cylinder to produce an explosive mixture where it enters into the ignition tube, ignition takes place and the engine starts. The valve *E* and the air outlet valve are then closed, and the gas main, which had been previously closed, is opened and gas allowed to flow into the gas bag.

Messrs. Tangye's self-starter consists mainly of an air pump worked by hand, by means of which the space behind the piston may be filled with gas and air under a slight pressure. Some of this mixture enters the ignition tube and is fired, giving the initial impulse, after which the engine continues running in the regular way. Messrs. Robey & Co., of Lincoln, England, to whose engines reference was made in the July number of this magazine, use on their large engines what is known as the Clerk-Lanchester starter, illustrated in Fig. 112. It consists of a chamber *A*, outside and separate from the engine, and of a capacity rather greater than that of the cylinder, with which it is connected by a pipe *E*, and check valve *W*. The crank being set

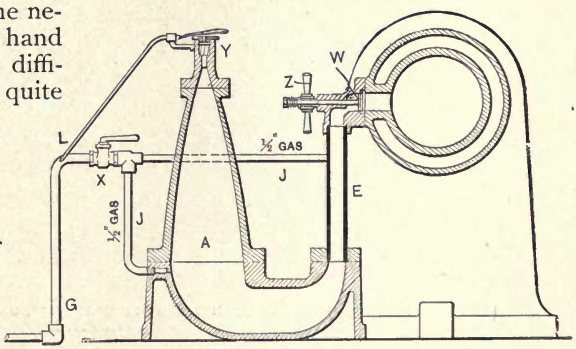


FIG. 112.—THE CLERK-LANCHESTER STARTING GEAR.

at about fifteen degrees, gas is turned on by a tap *X*, from the gas main *G*, and it flows into the chamber by the pipe *J*, mingling with the air therein and forming an explosive mixture. At the same time gas flows into the cylinder by the pipe shown. When the mixture is so far formed as to be inflammable, it lights at the jet *Y*, and a little later becomes of sufficient explosive strength. The tap *X* is then closed, and the ejecting pressure ceasing, the flame at *Y* shoots back, ignites the gaseous mixture in the chamber, and this forces the gas in *E* into the cylinder under a pressure of about fifty pounds per square inch, and forms there a compressed mixture which, on ignition, gives an average pressure in the cylinder of about eighty-five pounds per square inch, and starts the engine and its load. In the line of petroleum motors Germany would appear to have kept well abreast of other countries, and a number of German makers have established agencies outside of their own domain, notably in England, for the sale and general

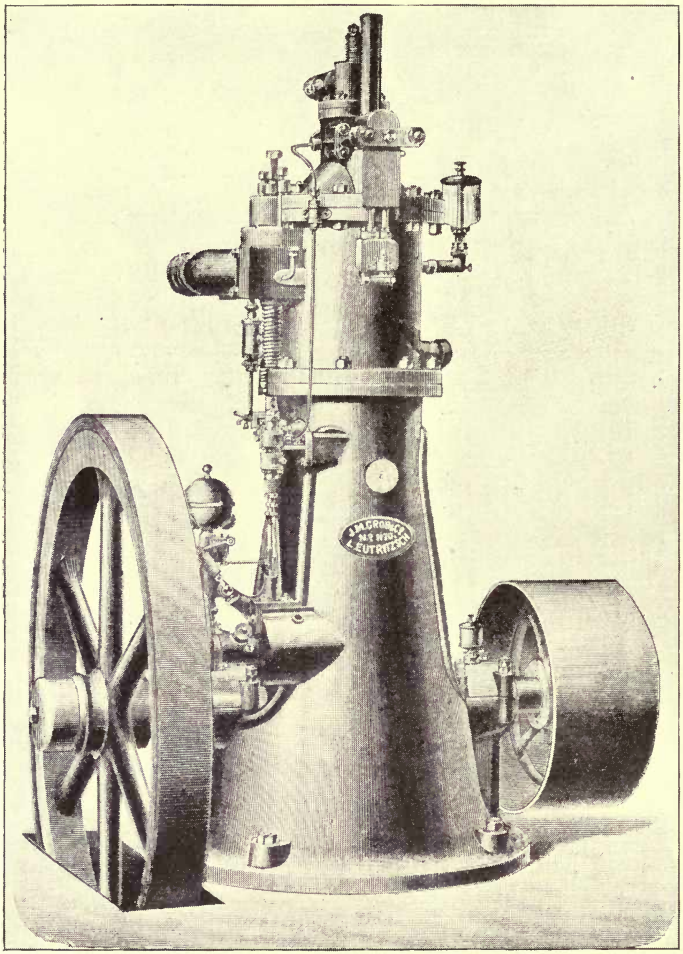


FIG. 113.—OIL ENGINE BUILT BY MESSRS. J. M. GROB & CO., LEIPSIC-EUTRITZSCH, GERMANY.

advertisement of their product, competing, thus, directly with a host of other engines in their own territory. Among these is the firm of J. M. Grob & Co., of Leipsic-Eutritzsch, who are building an engine which in Germany, at least, seems to be well known, and to have found considerable favor for all kinds of work—marine, stationary and portable. It appears, in fact, to be a modification of the Capitaine engine, already described in one of the earlier papers of this series.

Though on the market for only about two years and a half, something like 1400 of these engines are said to be now in use. The sectional view clearly explains the working mechanism. The engine belongs to that class of petroleum motors in which the oil is vaporized in a heated chamber before being drawn into the working cylinder, the vaporizing chamber being marked *V* in the illustration. Working, as the engine does, on the Otto cycle, it draws in air on its first down-stroke through the valve *A*, and petroleum through the atomizer *S*, the petroleum spray being vaporized in *V* before it mixes with the fresh air and enters the working cylinder. The vapor and air mixture is compressed on the next up-stroke of the piston, the air and atomizer valves closing automatically, and explosion of the charge at the beginning of the second down-stroke of the cycle is produced by some of the mixture having been forced into hot vaporizer, which serves the purpose of an ignition tube. The working stroke having been performed, exhaust during the second up-stroke of the piston takes place through the valve *E*, which is worked by a long shaft receiving motion from the crank shaft of the engine through intervening gear wheels. The valve rod is not connected to the exhaust valve, but simply strikes against the valve spindle and pushes it upward, the seating of the valve being effected by a spring. The valve is opened only once in every two revolutions of the main shaft. Heating of the vaporizing chamber is effected by the lamp *L*, and cooling water for the cylinder jackets enters and escapes through the connections *WW*.

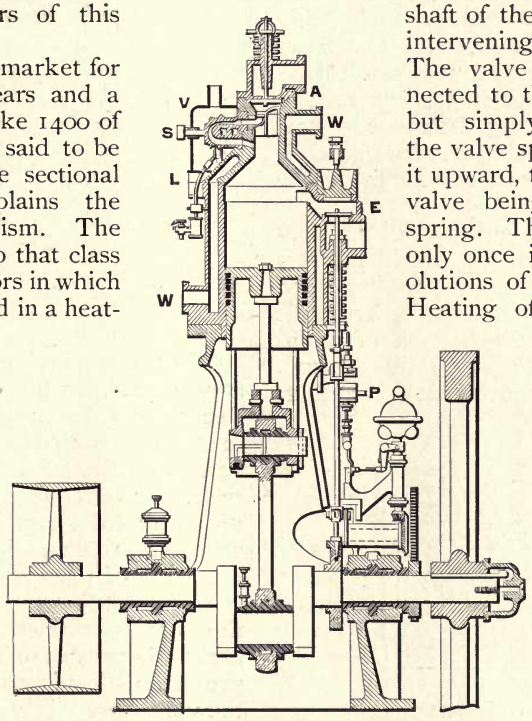


FIG. 114.—VERTICAL SECTION OF THE GROB ENGINE.

The oil pump *P*, which supplies oil to the vaporizing chamber, is controlled by the governor in such a way that the amount is varied in accordance with the demand for power. The oil used is of the ordinary kind burned in lamps for illuminating purposes.

(*To be continued.*)

RECENT IMPROVEMENTS IN WATER VALVES.

By John Richards, Mem. Am. Soc. M. E.

THE drawings from Fig. 1 to 5 show some water valves invented by Mr. C. I. Hall, of San Francisco, Cal., and employed by the Cahill & Hall Elevator Company, to hoisting or elevator machinery, in their practice.

These valves were aptly described by the inventor in one of his first specifications as permitting the water to flow only in the direction intended, which is the leading characteristic of all the designs.

The company are makers of "hydro-steam" elevators, in which the impelling force is steam pressing upon the water, which actuates the hydraulic pistons, the water by reason of its inelasticity performing the required function of positive movement and "abutment," the same as in the case of common hydraulic elevators. The direct steam pressure dispenses with pumps, accumulators and so on, such as are employed when the price of water does not admit of its use from the public service.

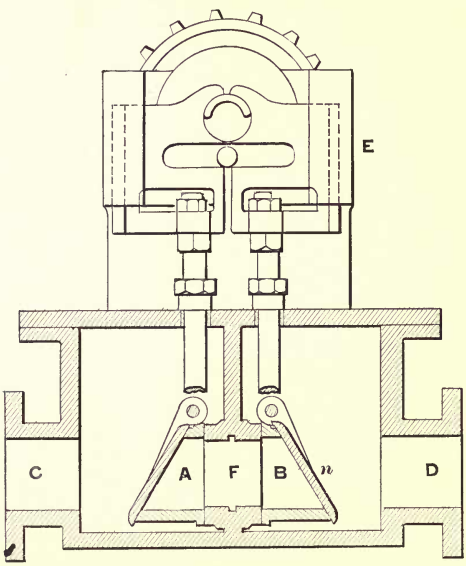


FIG. 1.

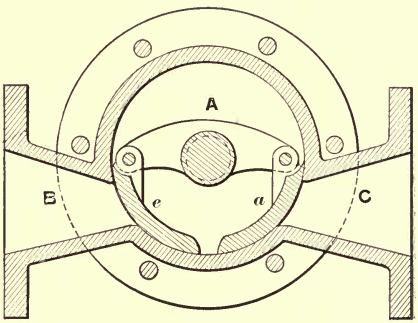


FIG. 2.

The water employed in the hydro-steam system, while inelastic in itself, does not produce regular or safe movement when controlled by common stop valves, for the following reason: Suppose, for example, a load is being raised, and the cage is stopped on the way to receive an additional load, as in the case of passengers getting on at the different floors of a building. When the cage is stopped there is an equilibrium between the load and the steam pressure acting on the water, but when the valves are opened to go on, or to go down, the static pressure will be insufficient to sustain the new load, and the cage will suddenly drop until the steam rushes in to check the back-flow of the water and balance this added load. For this reason common stop valves cannot be employed.

In the case of removing a part of the load during a trip of the cage the same difficulty occurs. The pressure at the time of stopping the cage remains in the steam receiver, and when valves are opened this force is too great for the reduced load, and the cage is suddenly shot upward until the forces are balanced. The present valves are em-

MODERN GAS AND OIL ENGINES

By Albert Spies, Mem. Am. Soc. M. E.

Eighth Paper.

IN connection with the different ignition methods referred to in the preceding paper, it may not be amiss to mention that in the case of engines using either flame or tube igniters the consumption of gas by the igniting or heating burners is an item not always duly taken into account, and may assume appreciable proportions. Where gasoline or some other oil is used in such engines instead of gas, and where the latter is not to be had, the gas flame must, of course, except in a few engines of special design, be supplanted by an oil torch, and the same additional fuel consumption, above that taking place in the cylinder of the engine itself, is there encountered, the torch, moreover, being a rather undesirable annex to the whole outfit. These circumstances have, in a great measure, helped to stimulate the improving of electric igniting devices, and several of them are now affording very satisfactory accounts of themselves. This much may already have been gathered from what has gone before. With the electric igniter there is, of course, to be considered the expense of the battery which furnishes the electric current, but this has been claimed, and with good reason, to be a very small proportion of the whole operating expense,—a much smaller one, in fact, than that represented by the gas or oil cost in a flame or tube igniter. It would seem to be a pretty fair conclusion, under the circumstances, that electric igniters are destined to a yet wider application and a growing share of favor.

Not less important than the methods of igniting are those of governing, and considerable ingenuity has been expended for years past in developing various contrivances designed to satisfactorily solve the gas engine governor gear problem. At first thought, some sort of throttling gear by which the gas or oil vapor supply to the cylinder is gradually reduced as the speed increases, and vice versa, is apt to suggest itself as a desirable one, and, as a matter of fact, many gears of this kind have been made and are used, both Lenoir and Hugon having followed this method of governing in their early engines. Its wastefulness, however, becomes apparent on even slight consideration, so that one may well wonder that at this late day the throttling governor is still countenanced in gas engine practice. It is obvious that if, with such a governor, the volume of gas or oil vapor admitted to an engine cylinder is diminished, the volume of air admitted is correspondingly increased, and it is well known, too, that the limits of variation permissible in explosive mixtures of gas and air are comparatively narrow, so that if, in a total volume of mixture, the volume of gas either exceeds or falls short of a certain, elastic proportion, no explosion can be produced. While, therefore, a gas throttling governor may either increase or diminish the force of the explosions in the engine

cylinder by varying the strength of the gas and air mixture between these limits, yet if one of the limits be passed, and the gas volume, for instance, be too greatly diminished, ignition of the mixture will be missed and whatever

to increase, gas being simply pumped through the cylinder and wasted until its proportion is again increased, by the subsequent opening of the gas valve to that point where the mixture once more becomes explosive.

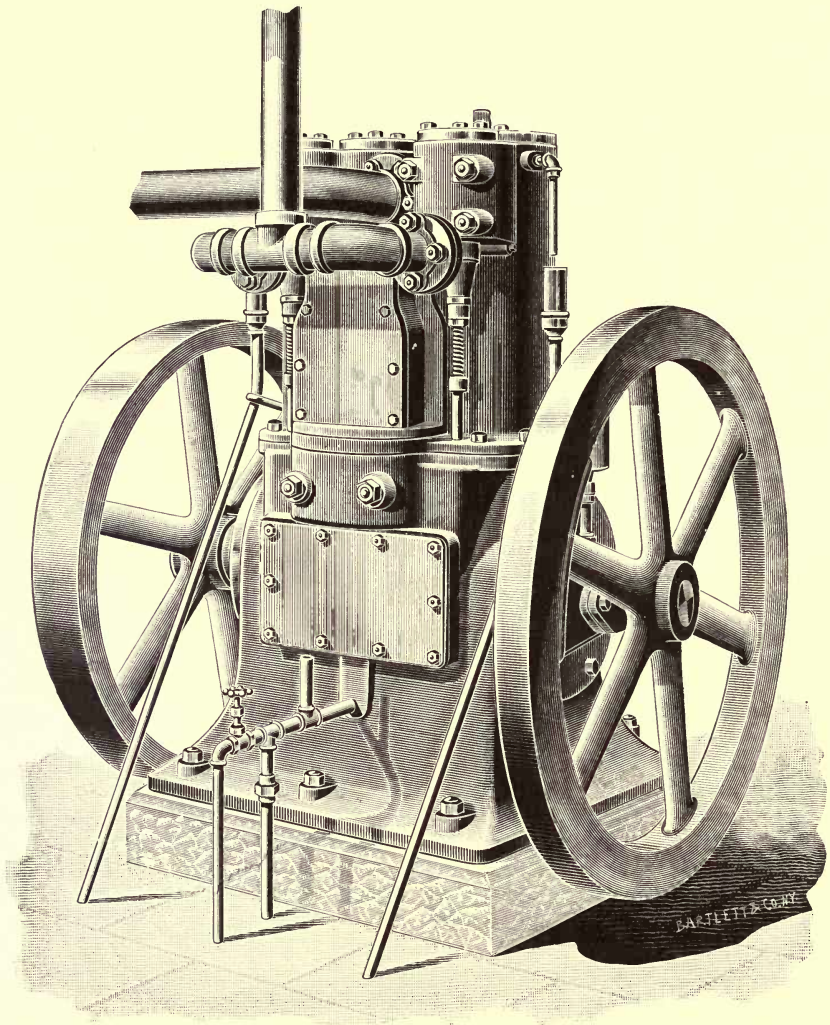


FIG. 115.—THE PITTSBURGH ENGINE, BUILT BY THE FUEL GAS AND MFG. CO., PITTSBURGH, PA.

gas has been taken into the cylinder will then be discharged into the exhaust pipe unburnt and without having given up any of its energy. Under these circumstances the engine will work exactly as though no gas whatever had been admitted, and the speed will cease

No better evidence is needed of the fact that the wastefulness of the throttling governor method has met with a fair share of recognition, than the extended application which for years has been given to what have been termed "hit-and-miss" governors. With

these the strength of the explosive gas and air mixture is never changed, but the number of explosions in the engine cylinder in a given time is varied to suit the prevailing requirements, being increased when the speed falls below, and decreased when it rises above a certain normal; or putting it in a slightly different way, when the speed falls off, the governing device hits the stem of the gas supply valve, causing the latter to open and admit gas into the cylinder, while when the speed becomes too high, the governor by changing its position, misses the gas valve stem, the valve consequently remains closed and no working charge reaches the cylinder.

One objection to this method of governing always has been that it gives the engine a jerky, unsteady motion which is fatal to success in electric light work, and in order to overcome this, some engine builders now provide the governor cam which strikes against the gas valve spindle with several steps, so that instead of being either full on or full off, the gas valve may be opened through intermediate degrees. The strength of the explosive mixture may thus be varied to some extent, but whenever the lower limit of gas percentage necessary to constitute an explosive charge is reached, the gas valve is closed entirely, and the engine then runs without explosions until the speed again drops. The stepped-cam governor, in fact, combines a throttling with a cut-off action.

The ideal method of governing, however, would seem to be one akin to that followed in modern, high-class steam engine practice,—one by which the strength of the working charge would be kept always the same and only the quantity for each working stroke would be varied. In all processes of combustion there is a certain percentage of oxygen, which, by combining with a certain percentage of combustible, produces a maximum effect, and any variation from these relative proportions will represent a loss of efficiency. This is fully as true of the combustion of gas in a gas engine cylinder as of the combustion of any other kind of fuel in any other place, and the economic bearing of maintaining a constant and certain strength of explosive mixture in gas engine work will, therefore, be at once recognized.

An engine in which advantage has been taken of this circumstance is that recently put on the market by the Fuel Gas and Manufacturing Company, of Pittsburgh, Pa., and known as the Pittsburgh engine. In external appearance it strikes one much as one of the well-known Westinghouse steam engines. As in these, a crank case encloses the bearings and lower end of the cylinders. This case is filled almost up to the shaft with a mixture of oil and water, into which the crank shaft and connecting rods splash at every revolution, so as to completely deluge the bearings, piston and interior of the cylinders, thereby not only affording copious self-lubrication, but also cooling the piston. Oil for the crank case is introduced through the main bearings, which are supplied from the only two oil cups on the entire engine. A simple pipe connection with a city main supplies the necessary water. Another pipe, serving to carry off the overflow, is made, by means of a funnel head, to indicate the level of the lubricants in the crank chamber.

All the Pittsburgh gas engines are built with two cylinders on a single shaft, and, as usual, abnormal heating is obviated by the employment of water jackets. Each revolution made by the engine operates valves admitting the gaseous fuel alternately to the one or the other cylinder. As the period of admission is controlled by a positive action, the crank shaft receives an impulse once each revolution, no matter what the load, but the energy of that impulse is predetermined by an independent piston valve. In order that the maximum amount of energy may be developed by the explosion of the gaseous fuel, there is, as already explained previously, but one value that the relative amounts of gas and air can bear to each other, and the company design their measuring piston valve so that, it is claimed, it always admits gas and air in their correct proportions for

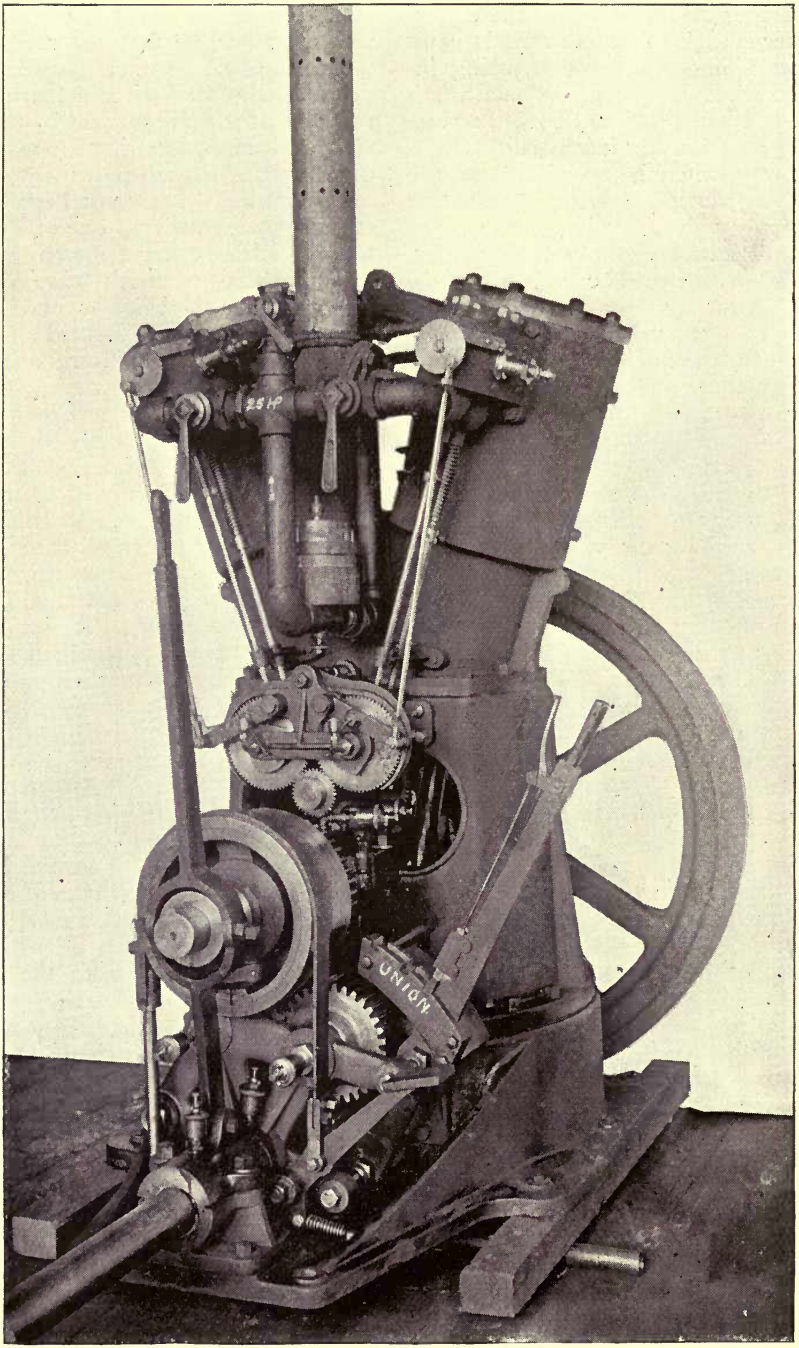


FIG. 116.—TWENTY-FIVE HORSE-POWER UNION MARINE ENGINE.

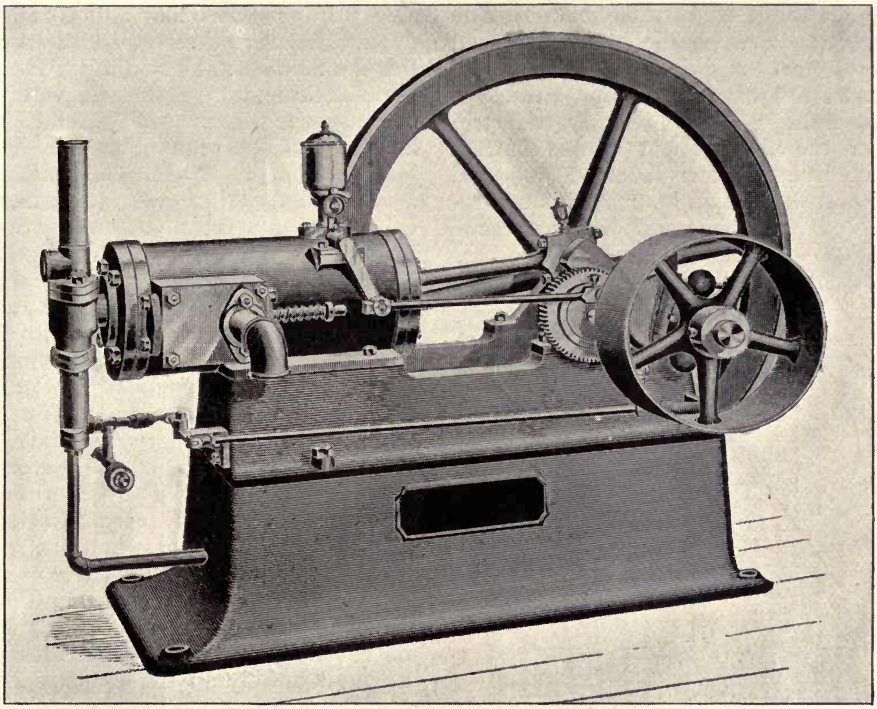


FIG. 117.—THE CHARTER ENGINE, BUILT BY THE CHARTER GAS ENGINE CO., STERLING, ILL.

producing the desired maximum result, but at the same time varies the total amount of mixture directly as the work of the individual piston stroke. The governor is mounted upon the shaft, between the cranks, and, by direct connection between the eccentric rod and valve stem, insures an accurate and positive travel to the measuring slide valve. The igniter employed is of the electric spark type. Unfortunately, more complete particulars of this engine are not available at the present time.

In connection with the Union engine, described in the preceding paper, and built, as there stated, by both the Union and the Globe Gas Engine Company, of San Francisco and Philadelphia, respectively, the illustration on the opposite page will prove interesting, representing, as it does, the latest type of double cylinder, marine engine of Union make, rated at twenty-five horse-power. This engine, according to advices received within the past few weeks from the builders, was completed only a short time ago, and is now in a schooner in San Francisco Bay giving highly satisfactory results. It is the first one of the kind that they have built, and is probably the largest marine oil engine now in use, except a four-cylinder engine of forty-five horse-power of somewhat different form which was turned out by the same builders a number of years ago. The main features of the engine are essentially the same as those of the horizontal Union stationary engine, shown in the September number ; the valves and igniting devices are similarly operated, and the same form of vaporizer as that then illustrated is used.

The propeller reversing gear shown tends to give the impression that there is considerable complication about the engine, but this will disappear upon closer study of the details. A muffler

around the exhaust pipe is used to deaden the noise of the exhaust. The schooner in which the engine is placed is 59½ feet long with 14 feet beam, and carries freight between San Francisco and Bodega Bay. On her trial trip over the Government course in San Francisco Bay she developed a speed of over 8 miles an hour. This was regarded as a very good showing, as the engine was new and stiff, and the boat was not built for speed. The owners

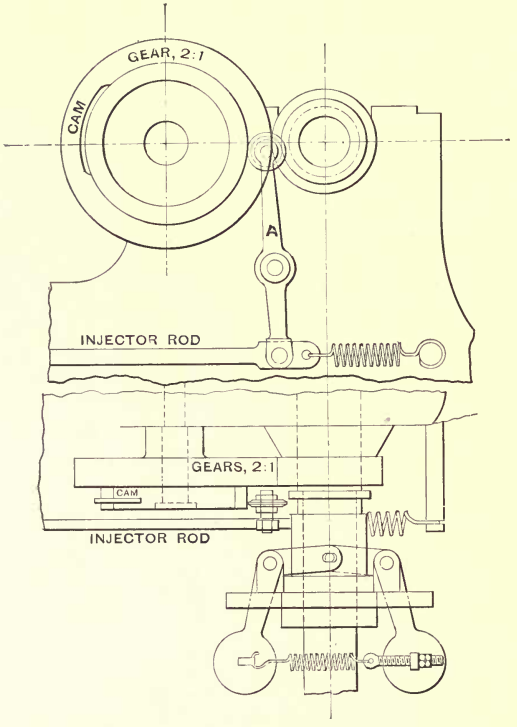


FIG. 118.—DETAILS OF THE CHARTER ENGINE.

of the vessel also have a 10 horse-power engine in one of their other boats.

As the last of the series of illustrations are presented those of the Charter gas and gasoline engine, which is made by the Charter Gas Engine Company of Sterling, Ill., and which in some respects is similar to the Caldwell-Charter engine described in one of the earlier papers. When using gasoline no carburetting device is used between the oil tank and the cylinder, but the oil is delivered directly into the suction pipe by a pump controlled by the governor, a few drops only being admitted at a time. There are three cut-offs between the tank and engine cylinder, viz., a cock at the tank, a throttle valve to regulate the amount of gasoline delivered, and the plunger of the pump just mentioned. The engine works according to the Otto cycle, the exhaust valve being pushed open at every other revolution by a rod worked through reducing gearing from the crank shaft. The arrangement of the gasoline pump and the manner in which it is controlled by the governor will be easily understood both from the general view of the engine and from the details shown in Fig. 118, the latter representing an elevation and a plan of the governor and its connections. The governor, it will be observed, is mounted on a sleeve on the main shaft, and when the governor balls, under the influence of unduly high speed, move outward, the sleeve is carried along the shaft and moves with it a cam roller, which is mounted loosely on the upper end of the rocker arm *A*. When so displaced, this cam roller is missed by the cam on the larger of the two gear wheels shown, and the rocker arm, which is connected with the injector rod operating the gasoline pump, remains undisturbed, and no gasoline is permitted to enter the suction pipe leading to the cylinder. When, on the other hand, the governor balls are in the position shown in the engraving, the cam on the larger gear wheel will, in the course of its revolution, come in contact with the cam roller on the arm *A*, force it over to the right, and cause a stroke to be made by the gasoline pump through the intervention of the injector rod. The displacement of the pump plunger then admits the proper gasoline supply to the suction pipe, and the entering air carries the oil along into the cylinder in which the mixture, after compression, is fired by a tube igniter. For engines above six horse-power a slightly different form of governor connection is employed, the working principle, however, being the same. The engine is turned out in sizes of from one and

one-quarter to thirty-five actual horse-power.

Before finally leaving the subject, the writer would attempt to forestall criticism on the score of incompleteness of the series of articles presented by stating that no attempt could be well made to embrace in them all the engines of the class considered which are now in use and built in different countries. It was deemed advisable, in fact, at the outset to try to present only engines of English and American make, and such foreign designs as were represented in English and American markets, and even this undertaking was found beset with many difficulties. Aside from the fact that the addresses of some makers of engines could not be ascertained, there were a number of builders who simply ignored requests for information, and others again who flatly declined to furnish particulars of any kind. That the list of engines considered in these articles is by no means comprehensive is, therefore, natural.

AN EVAPORATIVE SURFACE CONDENSER.*

By James H. Fitts.

THE condenser herein described was built at the Virginia Agricultural and Mechanical College, at Blacksburgh, Va., after some observations were made on the rate of evaporation of water at different temperatures, and with a current of air passed over its surface. Its performance has been successful to such a degree that this paper is presented, in the belief that it will be of general interest to the profession, and that it gives a practical solution of the question of condensation of vapor with a small water supply.

The condenser consists of two rectangular end chambers connected by a series of horizontal rows of tubes, each row of tubes being immersed in a pan of water. Through the spaces between the surface of the water in each pan and the bottom of the pan above, air is drawn by means of an exhaust fan. At the top of one of the end chambers is an inlet for steam, and a horizontal diaphragm about midway causes the steam to traverse the upper half of the tubes and back through the lower. An outlet at the bottom leads to the air pump.

The condenser, exclusive of connection to the exhaust fan, occupies a floor space of 5′ 4½″ x 1′ 9¾″, and is 4′ 1½″ high. There are twenty-seven rows of tubes, eight in some, and seven in others; 210 tubes in all. The tubes are of brass, No. 20 B. W. G., ¾″ external diameter and 4′ 9½″ in length. The cooling surface (internal) is 176.5 square feet.

There are twenty-seven cooling pans, each 4′ 9½″ x 1′ 9¾″, and 1 7-16″ deep. The pans have galvanized iron bottoms, which slide into horizontal grooves ¼″ wide and ¼″ deep, planed into the tube sheets. Wooden strips are fitted into the grooves below the bottoms. The tube sheets form the ends, and angle irons 1⅜″ x ¾″ x ⅛″ bolted to the galvanized bottoms, the joints packed with wooden strips, form the sides. The total evaporating surface is 234.8 square feet. Water is fed to every third pan through small brass cocks, and 1¼″ overflow pipes feed the rest. A wood casing connects one side with a 30″ Buffalo Forge Co.'s disk wheel, which is belted to a 3″ x 4″ vertical engine.

The action of this condenser is clear. The passage of air over the water surfaces removes the vapor as it rises, and

* From a paper presented at the International Engineering Congress at Chicago.

thus hastens evaporation. The heat necessary to produce evaporation is obtained from the steam in the tubes, causing the steam to condense. It was designed for the college shop engine, to condense 800 pounds steam per hour, and give a vacuum of twenty-two inches, but it was found practically impossible to get the long exhaust pipe air-tight, on account of its numerous connections. Direct connection was therefore made with the boiler. A number of runs of several hours' duration have been made with a boiler pressure of sixty to seventy pounds. The cooling water was run into a barrel placed overhead and drawn from the barrel. The water of condensation was weighed. The following gives average results :

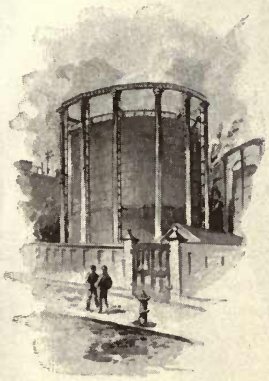
Boiler pressure, pounds per square inch per gauge, 65 ; temperatures in Fahrenheit degrees—steam, 311 ; cool-water (initial), 60 ; water in pans above diaphragm, 140 ; water in pans below diaphragm, 115 ; hot well, 149; air, 70; dew point, 62 ; working strokes of air pump, 90 ; revolutions of exhaust fan per minute, 740 ; velocity of air in feet per minute, 2300 ; quantity of air moved in cubic feet per minute, 6500 ; horse-power expanded in driving fan, ½ ; barometer in inches, 28 ; cooling water used per hour in pounds, 1350 ; steam condensed per hour in pounds, 900 ; vacuum in inches of mercury, 16½ ; vacuum reduced to barometer at thirty, 18½.

The overflow pipes for regulating the supply of water were found to be too small, so that at times some pans would be too full, causing waste of water over the edges, and at others the tubes would be uncovered, with reduction in efficiency. This loss of cooling water will account for the amount being so much in excess of the water of condensation. The amount of steam condensed, if there had been no waste of water, would have been about thirty pounds less than that shown.

Accurate analysis of the transfer of heat could not be made on account of this waste. An approximate analysis, however, shows that the cooling water required is practically equal in amount to the steam used by the engine, and since consumption of steam is reduced by the application of a condenser, its use will actually reduce the total quantity of water required.

The condenser is still in a crude form, and there are many improvements to be made in it. Enough has been done, however, to demonstrate that it is applicable in any situation, that it is not expensive to construct, is perfectly accessible for cleaning, requires small power to operate, and will give a vacuum of from twenty to twenty-two inches. The floor space required is moderate.

GAS AND OIL ENGINES.



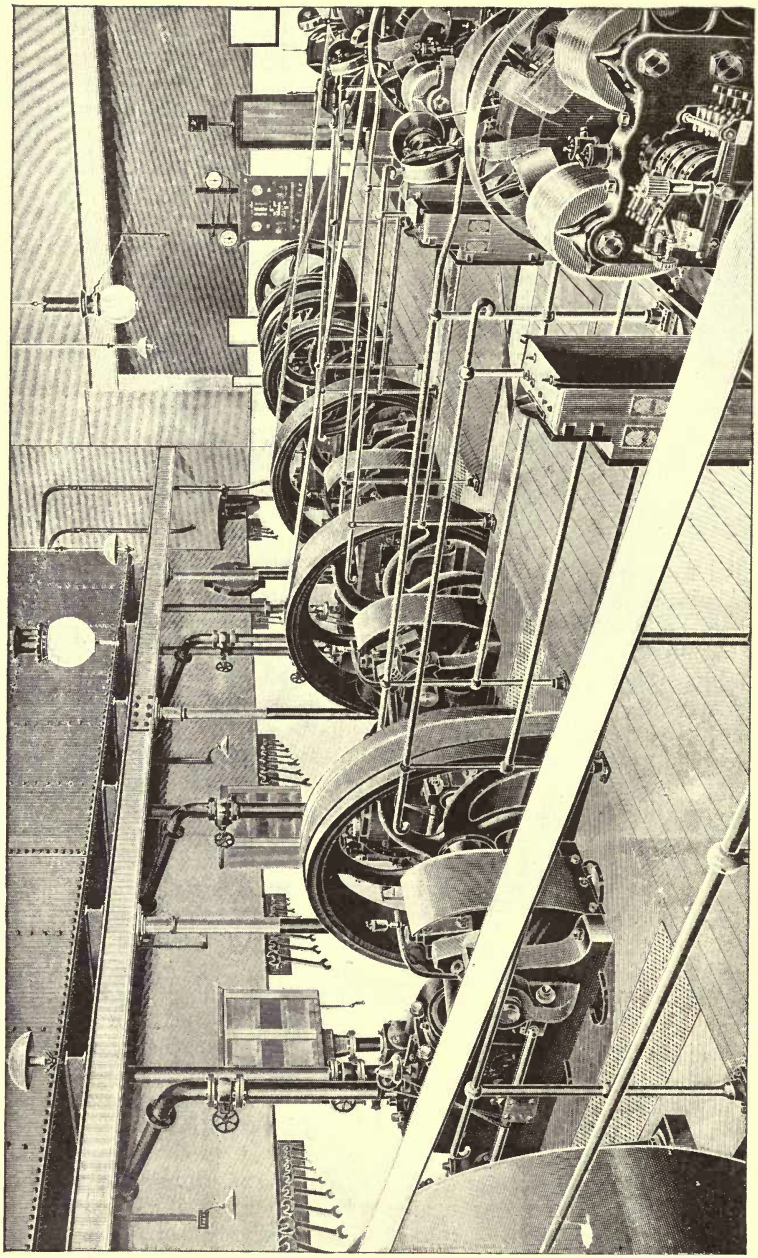
AT no time in the history of gas and oil engines has the interest in their application to every-day work been so strongly marked as at present. Together with electric motors, these engines have done much to displace small, and in many cases even large, steam engines, and power users have commenced to realize that for economical, reliable and convenient driving, engines of that class are entitled to very careful consideration. This is shown by every new contribution to the literature of the subject, and engineers' discussions of it at meetings of technical societies.

Among the latest, and perhaps most interesting, of these discussions is one which was held a short time ago before the American Society of Mechanical Engineers on the occasion of a "Gas and Oil Engine Evening," and to the facts presented at that time, and reproduced here, in part, it was thought well worth adding a number of illustrations of some of the most recent applications of the engines considered. These are all suggestive in their way and tell their own stories at a glance, more directly and more convincingly perhaps than pages of texts. The subject was introduced by Mr. S. A. Reeve who, among other things, said :—

"The status of the gas engine depends entirely upon the surrounding conditions. A plant exists merely because the sun shines, and the seed has been planted. Unless the surrounding conditions are favourable, the plant cannot exist, and the amount of its growth, and the character of its growth, depend entirely on the surrounding conditions. The gas engine follows this general law, in that its status to-day is what it has been forced to be, and what it has been allowed to be by general commercial and engineering conditions of the world. Practically all other power that is in use is steam power. I do not lose sight of the tremendous amount of water power that is in use. But water power is restricted to certain localities, and the gas engine is not. It comes into competition only with those forms of power which are applicable to almost any locality or set of conditions, and, aside from gas power, steam power is almost the only other occupant of that class of prime movers.

"The factory and the steam engine grew up together, and the idea that we carried in our minds of a commercial manufacturing plant, driven by any power, was a set of tools, driven by a central motor through the medium of a line of shafting and a number of belts. That scheme of industrial works grew in size and importance until it had reached tremendous proportions, and in certain lines of industry it still survives, and will continue to survive in the future in still larger sizes, and on a still more important scale. But for the vast majority of industries, these species of manufacturing which involve a varied number of processes and departments, and involve the production of a comparatively complex commodity, such, for instance, as the building of steamships or railway cars, or the complicated machines involving woodwork and ironwork and steel-forging work, and all that sort of thing, the modern factory is a collection of factories.

"The various factories may be merely departments, merely different rooms in one building or on one floor. But, at any rate, the factory now consists of a large number of departments, and those



CROSSLEY GAS ENGINE ELECTRIC LIGHTING PLANT, LEICESTER STATION, MIDLAND RAILWAY, ENGLAND.

departments are quite distinct. They often run entirely independently, have separate foremen or superintendents, run different hours, and have different classes of labour. In some, labour is a small item, and power is larger. In others, power is a small item, and labour is the principal feature. All these various conditions make it almost impossible for such an establishment to be driven by one central prime mover.

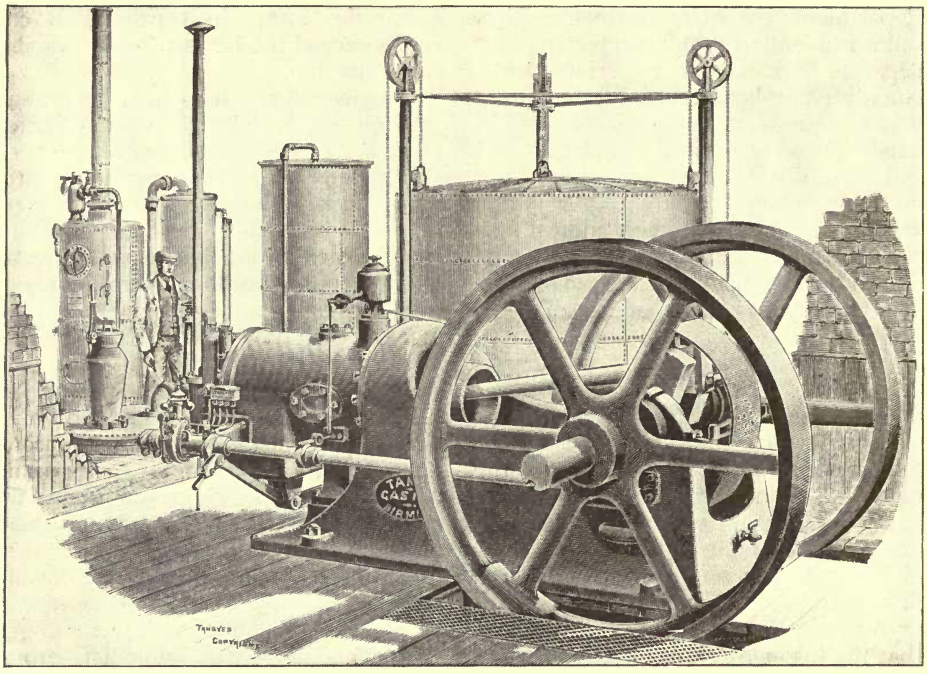
"In the first place, distance of transmission comes in and consequent losses. In the second place come in varying conditions. Every engineer knows that no piece of apparatus can work well under varying conditions. We have, therefore, seen grow up the modern industrial works in which power has to be transmitted quite a distance, and subdivided among a large number of different sorts of tools. This was first attempted by shafting and belting, or by rope drives. But it is evident that the losses by transmission are very great. Consequently we have seen other schemes tried. First came the subdivision of the steam engine itself into a large number of units, and we have only to look about us in large factories to see steam-driven plants where the power is furnished from the central boiler plant to anywh ere from ten or a dozen to 70 different engines scattered all over the works, sometimes 20 or more in one room. Sometimes the losses in steam transmission are, under average conditions, less than for shafting and belting. Of course, no cast-iron rule can be given for all conditions. But the subdivided steam plant has come in to stay. Of later years, superseding the subdivided steam plant, comes in, first, compressed air, and then electrical transmission and subdivision of power.

"I have given the résumé of the changes of the power question to show that the problem of the present is economical transmission of power, not economical development of power. Of course, economical development at the original point of production is of great importance, but it is vastly more important to transmit it economically, because the losses in transmission can easily exceed the largest losses possible in production.

"Those of you who have spent any time on the problem of the subdivision of power or its transmission, have seen that none of the systems heretofore provided satisfy the question. They all involve tremendous losses in transmission. They all involve heavy first cost, heavy expenditure for generating plant, transmission plant and redeveloping plant at the other end. For instance, in electrical transmission, if your total works need a thousand horse-power, besides your thousand horse-power of boilers, you must follow with a thousand horse-power steam engine, a thousand horse-power generator, your mains for carrying the electric power, and then, on top of that, a thousand horse-power of motors. That is, of course, losing sight of all small factors and percentages of loss. The present status of gas power, and also of its immediate promise for the future depends upon this statement of the problem in this part—that gas powers offers the ideal solution for the subdivision and transmission of power, the mechanical difficulties being, for the time, lost sight of.

"In other words, let us suppose that a large industrial plant requiring, say, 1000 horse-power, subdivided into, say, 50 different units which are utilized at various points, at different buildings, on different floors, at different speeds, for different hours during the day, under different conditions of varying and steady load—suppose that in such a plant as that, we install a 1000 horse-power gas generator or its equivalent, and then lead from it, or from the holder to a large number of gas engines, large central gas mains—it is evident that the first cost is away below that of any system, with the possible exception of the subdivided steam plant, where our boiler plant corresponds to our generating plant, our steam mains to our gas pipes, and our steam engines to our gas engines.

"But there is one big advantage which a gas plant has over a steam subdivided plant, in point of operation,



A 40 H. P. TANGYES GAS ENGINE AND GAS PRODUCER PLANT. BUILT BY MESSRS. TANGYES, LTD., BIRMINGHAM, ENGLAND.

and that is, that in the steam subdivided plant, no matter how large a proportion of the load be off, the central generating plant must be run, and the fixed charges of running cannot be altered. Steam must be kept up, the boilers must be kept hot, the stack, if there be one, must be kept hot, and the labour must be there to take care of the whole matter. I have myself tested one factory in which, for a large proportion of each day, the efficiency for the transmission of the power between the boiler plant and the work was 5 per cent., simply because they had to keep the whole plant going in order to move one small department.

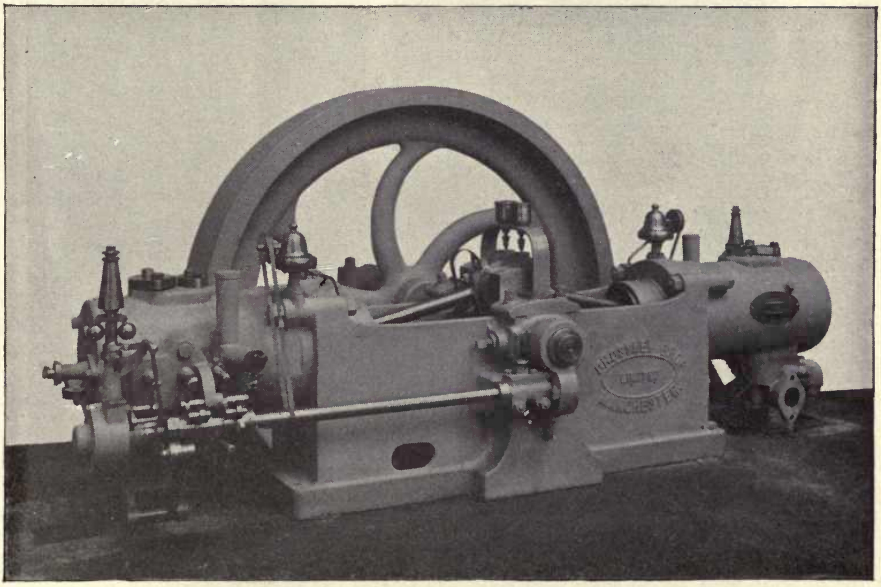
"With the gas plant that entirely disappears Your gas generator works for a certain number of hours a day, on whatever load or capacity is best suited to produce maximum economy, and as we all know, there is only one point in capacity in which any apparatus can work at minimum economy. During those certain number of hours a day the generator makes gas and stores it in the holder. The gas generating plant is entirely unconscious of the consumption of power, provided it be large enough to fulfill all demands. The consumers of power, the foremen of different departments, are as unconscious as is the generating plant of the consumption of power. They simply know that all they have to do is to turn on their gas and start their engine. They may run 24 hours in a day, while the gas generator runs eight, provided the total maximum production of the gas generator is large enough to cover the whole output of power.

"Comparison between such a gas plant and any plant relying upon transmission and subdivision of power by compressed air or by electricity, or by any scheme wherein the power is first developed by the steam engine, and then converted into another form, and then converted back again, is really hardly possible from the economical standpoint. The operation of any such

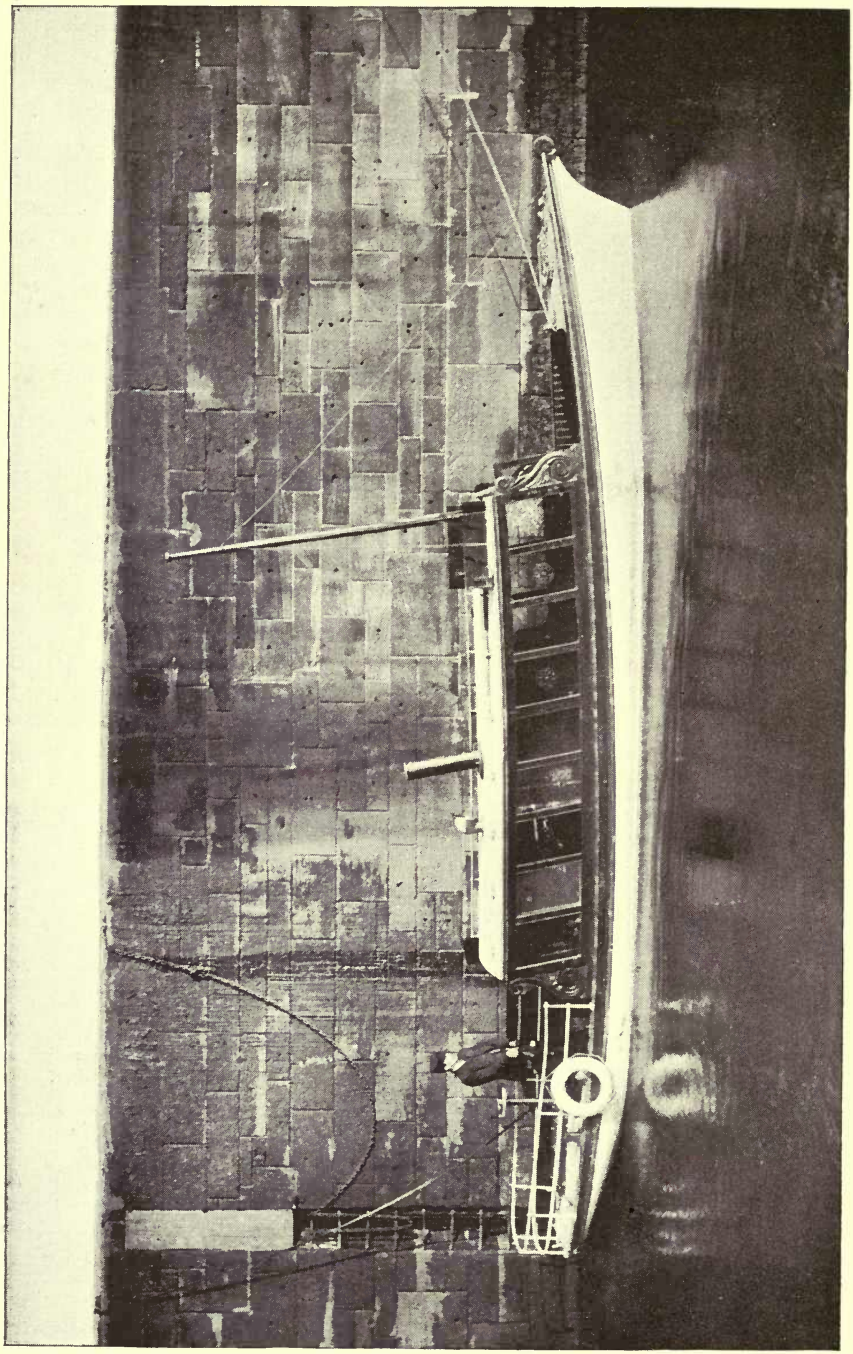
gas plant would be incomparably more economical than that of the compressed air or the electrical or the hydraulic system of transmission of power. I have entirely left out of the question the mechanical side of it, which I purposely wished to do. But for the merely commercial side there is an absolutely unlimited field for the development of power and its transmission and subdivision in industrial works by means of the gas generator and the gas engine.

"In nearly all large textile mills in New England, and in a great many other forms of industry, steam is used as much, and sometimes more, for heating purposes, and boiling and dyeing than it is for power. In fact, the big promoter of steam power in New England, where it has proved an indispensable auxiliary of water power, is the fact that the steam had to be had anyhow. That is true also of compressed-air plants. There are a great many factories where compressed air is indispensable for blowing, furnishing draft, cleaning, and innumerable purposes to which it can be applied, and in a great many plants compressed air is used to transmit and subdivide power where no other system would be tolerated, simply because the compressed air has to be there anyway, and, this being so, they might a great deal better use the compressed air for power.

"The same thing applies to electricity. Those factories relying on the electric current entirely for light may often bring the power question into secondary importance compared with light. If they have got to have their central engines and generators and mains for the productions and distribution of light, and if they need light more than power, then, of course, the electrical transmission of power is the thing, without regard to the general arguments against it. But this same factor of the correlation of the system of transmission of power, and the system of transmission of other forms of energy needed in the works, applies also to gas. In fact, the gas producer has reached its present state of perfection largely because of the fact that gas is the most economical form of fuel for a large number of industrial purposes—metallurgical, for glass works, and for many kinds of cooking and heating and baking, where exact control of tem-



A DOUBLE-CYLINDER OTTO ENGINE. BUILT BY MESSRS. CROSSLEY BROS., MANCHESTER, ENGLAND.



THE OIL ENGINE LAUNCH "PRIESTMAN," ON THE THAMES, ENGLAND. ENGINES BUILT BY MESSRS. PRIESTMAN BROS., LTD., LONDON.

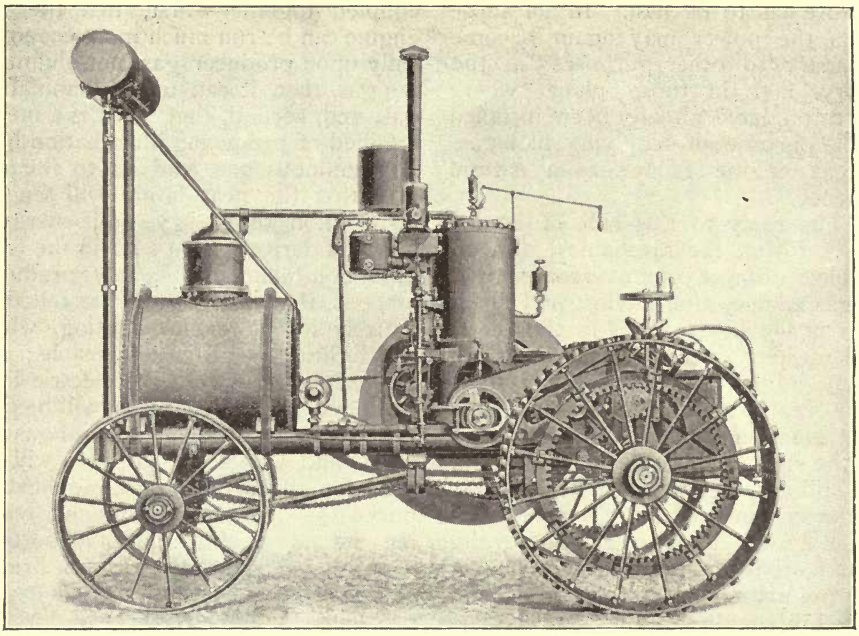
perature has to be had. In all those plants the power may again become secondary to other purposes in the factory, and in those plants where generators have already been installed for the purpose of supplying fuel gas, the gas engine follows as a natural sequence.

"The reply to this side of the discussion is that the mechanical difficulties have not yet been overcome; that the gas engine, after having had spent upon it the best energy in the line of mechanical engineering which the world has been able to produce for some thirty years, is still more crude in a great many mechanical features than was the steam engine of a century ago. It is still very heavy. In nearly all of the devices only one impulse is received by the fly wheel for every two revolutions, so that the fly wheels are heavy. The regulation, as a rule, is accomplished by simply dropping out a certain proportion of the impulses, instead of varying their strength, and the necessity for the ignition of the charge in a minute fraction of a second has led, until very recently, to extreme uncertainty in the matter of ignition and also in the question of perfection of combustion. The last is not so marked a feature, because, even with poor combustion, the gas engine is an exceedingly economical prime mover, but the mechanical difficulties still stand in the way of the accession of the gas engine to the proper field in which it belongs; that is, the universal factor for the production and transmission and subdivision of power in industrial works.

"At the risk of being considered rather superficial in skimming over this subject, I will take one step into the future and say that while gas engines have hitherto been almost entirely run with illuminating gas, yet already considerable has been done in the way of supplying gas engines with producer gas from special producers built for that purpose. There has also come upon the field—I will just mention it—the incandescent gas burner—that is, it has just begun to attract wide attention as being an established fact. These two coupled together—first, that the gas engine can be run much more economically upon producer gas, not illuminating gas, than it can upon illuminating gas, and, second, that there is a means attained of producing illumination by a non-luminous gas, lead us to the surmise that the near future will see the distribution of energy—all energy—which is derived from coal in the form of a non-luminous, cheaply produced fuel gas, that this gas will be relied on entirely for power, for lighting, where gas lighting at all is permissible; and where it is not, where the electric light is needed, that electric light will be produced through the medium of gas engines, and that this same gas will be used for all sorts of fuel and heating purposes—domestic heating and cooking and industrial heating of all sorts.

"I have tried to make as brief a statement as I could of the gas-engine problem as it appears to me to-day, not on the basis of the condition of the gas engine itself, but as a statement of its possibilities, the demands which are going to be made upon it in the near future, and what the near future may bring forth in the way of a powerful auxiliary to aid in the adoption of the gas engine as the universal prime mover."

Prof. Wm. S. Aldrich said: "Some of the chief difficulties to the extended introduction of the gas engine have been gradually removed by the improvements in methods and apparatus for the manufacture of producer gas on a small, yet economical, scale. In this, as in other branches of engineering, the law of supply and demand operates to mutual advantage, and isolated gas-engine plants are rapidly coming to the front. On the other hand, for the distribution of power from a central plant to greater or less distances, gas offers peculiar advantages. There are practically no losses in distributing the gas in pipe lines, except leakages, which can affect the economy of the distribution. Losses of pressure and temperature changes do not in the least affect the economy of the gas engine at the end of the line. Therefore, the distribution of power by



A GASOLINE TRACTION ENGINE. BUILT BY THE VAN DUZEN GAS AND GASOLINE ENGINE CO., CINCINNATI, OHIO, U. S. A.

gas, and its utilization by gas engines, scattered over a widely extended area, may come to be a rival of some of the other methods. And the facility of storage and use of gas for heating are additional advantages.

"It seemed doubtful for a long time whether gas engines could be made and economically managed in large units; but their present use up to 300-horse power and the contemplated manufacture of gas engines of 500 horse-power and upwards, leave no room for serious doubting. But it is open to discussion whether there is the same inherent gain in economy in the use of large gas engines as in the case of steam engines. Of course, on the general principles of power production, large units are more economical per horse-power than small units. Nevertheless, there is scarcely an argument advanced for the use of large steam engines that can be similarly advanced in the case of gas engines.

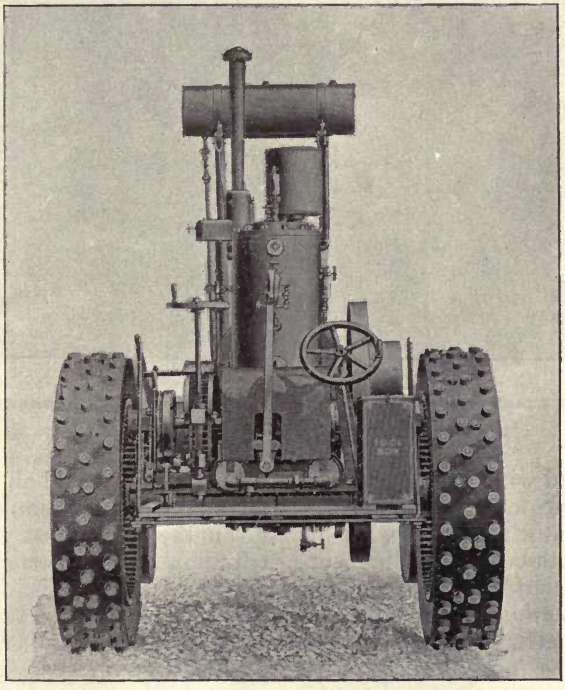
"In the matter of arrangement of gas-engine cylinders, there is undoubted preference manifested for the vertical type, and in pairs, with cranks at 180 degrees apart. Four-cylinder or quadruplex gas engines are being seriously considered, to gain an additional advantage along the same lines as the two-cylinder, or duplex type, namely, a greater number of explosions per revolution, and, consequently, an increased opportunity to control the supply and explosions according to the load.

"As rotating or rotary gas engines have been suggested, it may be well to note some of the advantages arising from using the explosions of the gas in much the same manner as the Pelton wheel utilizes the steadily applied impact of the water. The losses due to connecting rod mechanisms are eliminated; the highest speed may be obtained and controlled—especially to be desired in direct connection to dynamos; multiple discharge jets (or explosion pockets) may be arranged, as in the Pelton wheel; the force of the explosion may be most directly utilized in a tan-

gential manner; the internal friction will be reduced to a minimum; the best opportunities will be presented for regulating against the rapidly varying loads of electrical supply service; and, probably, a greatly increased economy will result in the use of gas.

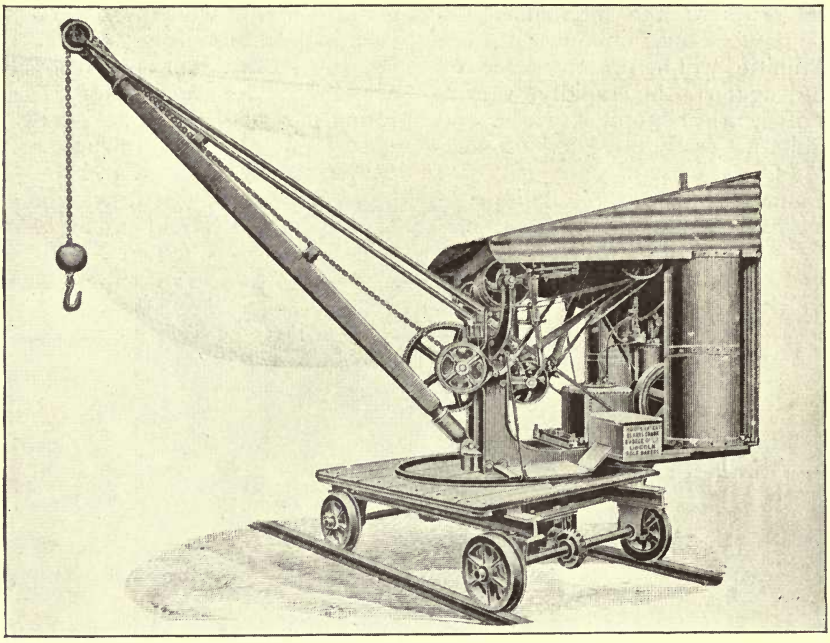
"In matter of speed regulation, gas engines have had an unenviable reputation, more due to the inherent difficulties of control than to any lack of inventive ability along this line. Always single-acting, frequently run at low speeds, and sometimes with rapidly varying loads, it is not difficult to understand that during one or more strokes the supply of gas may be entirely omitted, and the unusually heavy fly wheel drawn upon to meet the periodic variations in the supply of energy.

"Respecting the conditions of maximum economy in the use of gas, it has been found that there is a certain best load, for any given engine running at a given speed, at which load there is the least expenditure of gas per horse-power per hour. In this way it is possible to establish a very satisfactory basis for rating gas engines, that is, by their most economical performance. If gas engines could be tested and the curves of performance plotted, the whole gas-engine business would at once be placed on as satisfactory and substantial a basis as is now the case with turbines. The establishment of such a gas-engine testing plant is urgently needed. It would go far towards giving much needed additional encouragement to well-directed efforts in the development of the gas engine, as well as serve to forestall fruitless attempts in the same line."



FRONT VIEW OF THE VAN DUZEN GASOLINE TRACTION ENGINE.

Mr. W. Lawrence Wildy, representative of Messrs. Richard Hornsby & Sons, of Grantham, England, builders of the Hornsby-Akroyd oil engine, said:—"Most of you know, doubtless, that the producer is an ordinary cylin-



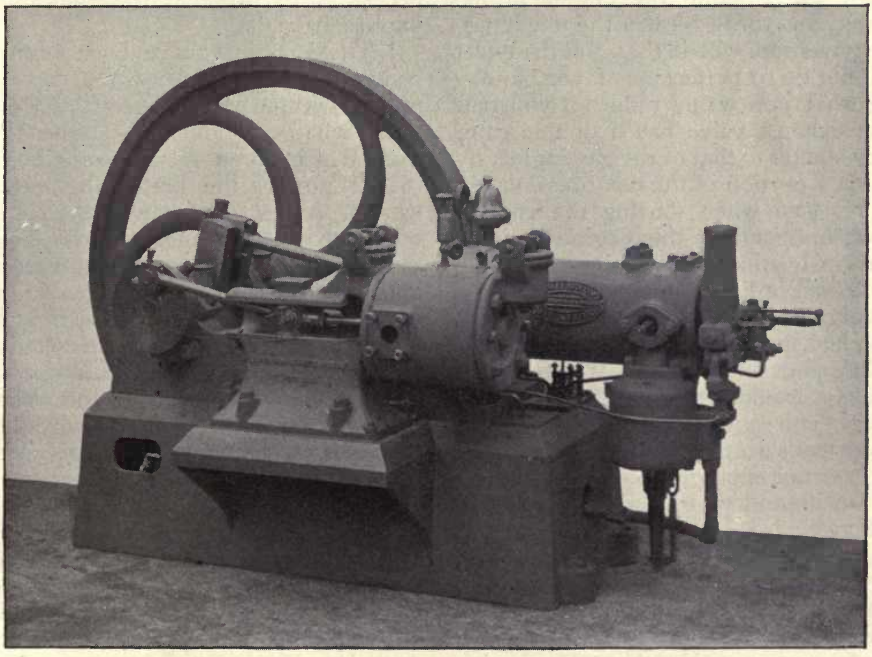
LOCOMOTIVE CRANE, WORKED BY A ROOTS OIL ENGINE. BUILT BY CLARKE'S CRANK AND FORGE CO., LTD., LINCOLN, ENGLAND.

drical vessel lined with fire brick, and more or less intricate in shape, according to the inventor's idea of what his patent is, and with certain cooling surfaces, or heating surfaces, or conducting surfaces, or something; but you will find 150,000 patents in the patent journal, doubtless, and they have all got something about them. But the simplest producer I have ever used was a column of fuel about 10 feet high. The fuel we used was coke—the coke which after distillation of the gaseous product was a residue which went to make the cost of the production of gas a mere cipher to the corporation running that gas concern. In Leeds, where I had my experience principally, the gas which was distributed through the houses cost nothing in the holder—it was all profit. I have seen the figures, and I have gone into it with the chairman of the Gas Committee of the Leeds Corporation, and it is a fact that it was a decimal short of nothing in the holder.

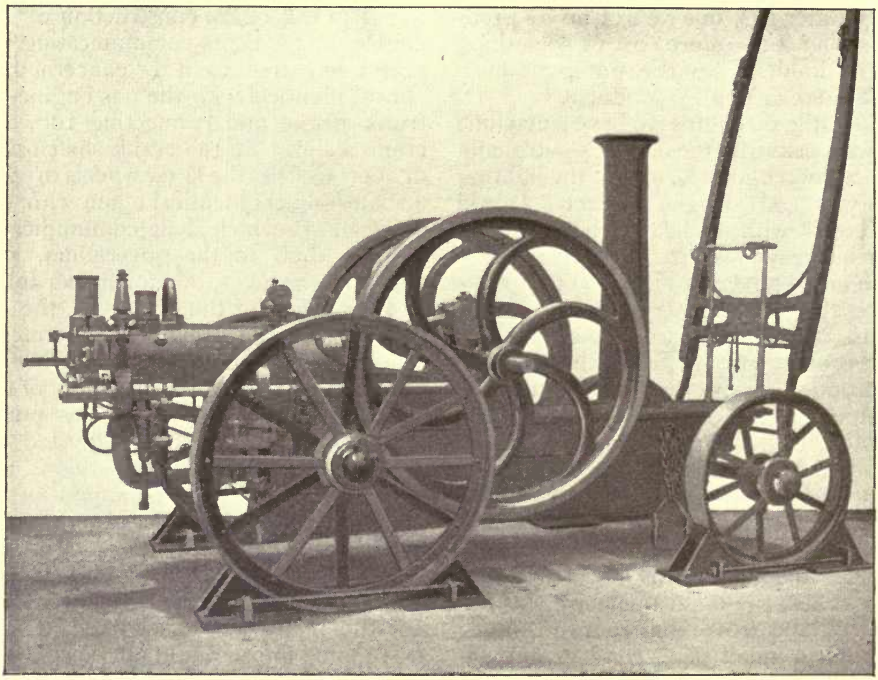
"The by-products from making the bituminous gas were so valuable at that time, that they paid all the expense, interest and depreciation of plant, and the gas in the holder cost nothing but distribution and collection of accounts. We were using enormous quantities of gas for welding steel tubes. We make tubes of varying diameters from 20 inches to 60 inches, and these varied in thickness from $\frac{5}{16}$ to $\frac{3}{4}$, and we welded these with the ordinary coal gas, and our gas bill ran from £6000 to £7000 a year. I got hold of this water-gas process, as it was used in Germany at the time, and I saw that it afforded a very good heating medium, very cheaply produced, and we went in for a plant there. The plant was a magnificent success, so far as we were concerned. It reduced our gas bill from between £6000 and £7000 to just over £1000 a year—fuel, interest, depreciation, labour, distribution—everything concerned came just over £1000 a year, or something under one-sixth of what we paid before. The gas cost us on an average about three pence halfpenny per 1000 cubic feet. We made

only water gas, but we got no by-products, and it therefore cost us something in the holder. In the water-gas business there are no by-products.

"In the oil engine we have a machine which works with the ordinary petroleum of commerce, that is, any of the lighting oils which are in the market. It will also work with the heavier oils up to the specific gravity of .9, and it will work with an oil having a flash point of anything that the ordinary oils have, and up to 320° Fahr. is a pretty strong oil. The process through which this oil goes to produce its power is as follows :—The engine is provided at the back of the cylinder with a small cylindrical chamber, which we call the vapourizer. On to this vapourizer is fixed a valve chamber, which really holds two valves, and which are the governour valves of the engine; the one opens inward to the vapourizer, the other opens by the action of the governour outward, and, through a small pipe, conveys any oil which is not required, back into the tank from which the pump has drawn it. The rest of the construction of the engine, so far as its communicating the power imparted to it is concerned, is almost identical with the gas engine—a trunk piston and connecting rod, and crank shank ; on the crank shaft a pair of skew wheels, the skew wheels driving a shaft—almost identical again with the gas engine—which shaft communicates motion, first, to the governours, and then to two valves, one for the air inlet, and the other for the exhaust ; the air inlet cam, at the same time, operates a small pump, from ⅜ to 1¼ inches in diameter, according to the power of the engine to be developed, and this pump has a stroke which can be adjusted by the regulation of the screw—that is, the oil pump—so that the amount of oil which is injected into the vapourizer is exactly in proportion to the power the engine requires. Suppose you are running the engine at half power, you run the pump at half stroke ; if you are running the engine at full power, you run the pump at full stroke, that is, if you know you are going to do so. But



A CROSSLEY OTTO GAS ENGINE AND AIR COMPRESSOR COMBINED.



A CROSSLEY OTTO PORTABLE GAS ENGINE.

if you are running the engine at full power, and throw off half the machines, the governour will do that, but the effect will not be so perfect as if you, knowing what you want, reduce it yourself. The exhaust valve has a double cam, very similar to that of the gas engine, by which a portion of the compression can be released when starting the engine. Now, in operating the engine you begin by heating the vapourizer with a lamp—an ordinary paraffin lamp with a circular wick—to which a small fan is attached, producing, for the time being, a little petroleum forge. It takes from five to ten minutes to heat that vapourizer. The only process is to fill the lamp and turn the fan handle. As soon as it is hot enough, you can turn your fly wheel, and your engine goes off at full cock; it is ready immediately, and it goes off at full power then and there, governing itself. The continual combustion of the oil in the vapourizer restores to the vapourizer the heat which has been extracted by the vapourization of the oil and the heating of the air necessary to produce the subsequent explosion.

"These engines have been running continuously for two months, day and night, without stopping, without any hitch whatever, and the higher the work that is taken out of the engine, up to full power, the better the engine works. At very low powers the engine will want a little nursing, perhaps, but at full power she will work right along. We start our engine at 5.30 in the morning, and the men come in at six o'clock, and she is never looked at again, except when the man goes in at dinner time and oils her, and at half-past five, when he goes to stop her, and there is no outside flame, no exposed red heat or dangerous flame of any sort about the engine."

Asked what he meant by nursing, Mr. Wildy said that if the engine had to run light for five or six hours, which probably no sane man would do under ordinary circumstances, it is possible that he may want to put a little brake onto the engine or some-

thing of that sort—to put a little work on her.

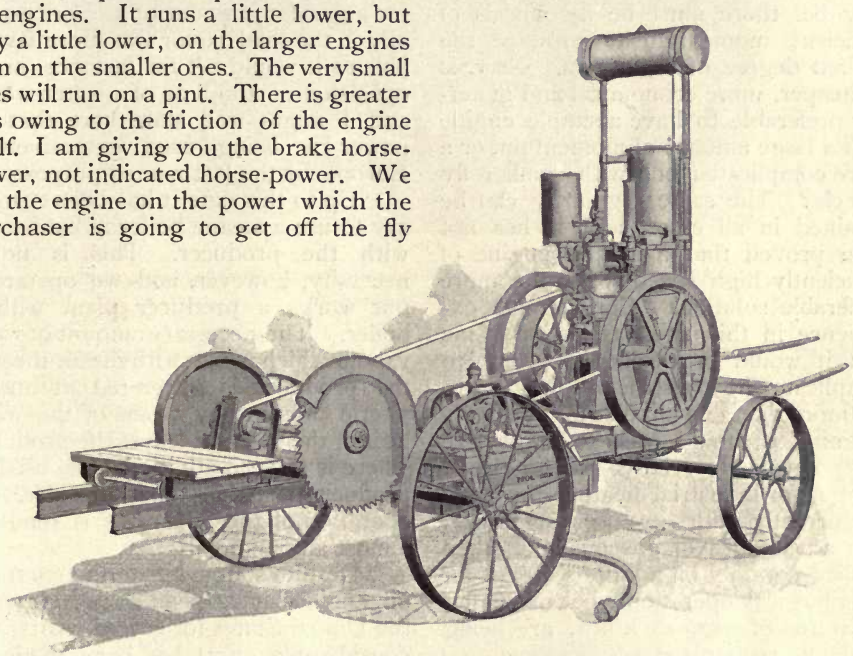
Asked if there was any residuum in the cylinder, he said :—"None whatever. We have run for two months and there was not as much as you could wipe off with your hand.

"The consumption runs about seven-eighths of a pint of American daylight or water-white per horse-power on all sizes of engines. It runs a little lower, but only a little lower, on the larger engines than on the smaller ones. The very small ones will run on a pint. There is greater loss owing to the friction of the engine itself. I am giving you the brake horse-power, not indicated horse-power. We sell the engine on the power which the purchaser is going to get off the fly wheel. He doesn't care what the power is in the cylinder. A 16 horse-power engine uses just .8 of a pint.

"In Russia they are adopting these engines and we cannot keep pace with them. With us in England it is a matter of consideration, because the oil which I understand you give about 7 cents a gallon for, costs us about 6 pence half-penny a gallon. They are doing wonderfully well with the engines over there. Every class of power-user is adopting them, to the rejection of all steam engines, up to 50 or 60 horse-power. They are in the hands of stablemen, gardeners, coachmen, all sorts of people, who, after they are once instructed, know what to do.

"The pressures in the oil engine are rather lower than in gas engines. In the Scotch gas I have had as much as 210 pounds initial pressure in the gas engine. The consequence is that the terminal pressure is so high that the exhaust becomes noisy."

The following discussion was contributed by Mr. Paul Winand, superintendent of the Otto Gas Engine Works, Philadelphia, U. S. A. :—



A VAN DUZEN PORTABLE GASOLINE ENGINE, SAW AND PUMP COMBINED.

"Concerning gas lighting by incandescent burners, I know by actual experiment that the temperature obtained from producer gas is not sufficient for the purpose. On account of the large percentage of inert gases which it necessarily contains, it is not even economical to enrich it for lighting purposes. However, by reason of the cheapness of the power obtained from this gas, electric lighting is generally the best possible way of providing light in such an installation. Pure water gas, though it can well be used in incandescent burners, is more expensive per heat unit, and, on the

whole, cannot compete with producer gas.

"It is generally thought that by increasing the number of impulses, the gas engine can be greatly improved as far as regularity of motion is concerned. This is only an argument of relative value, however, as the question resolves itself to this :—

"Whatever the number of impulses may be, there must be fly wheels of sufficient momentum to produce the desired degree of regularity. Now, is it cheaper, more economical and generally preferable to have a simple engine with a large amount of momentum, or a more complicated one with smaller fly wheels? The same regularity can be obtained in all cases, and it has not been proved that a simple engine of sufficiently high speed is not the more preferable solution. Considerable experience in this line has shown to me that it would be decidedly wrong to complicate the construction in order to get more than one impulse for each revolution. I should wish to emphasize the point made relative to the use of fuel gas for industrial heating purposes concurrently with its use for power. The advantages of gaseous fuel when applied not only on a large scale, as for metallurgical operations, but in smaller apparatus of various kinds, are being gradually recognized.

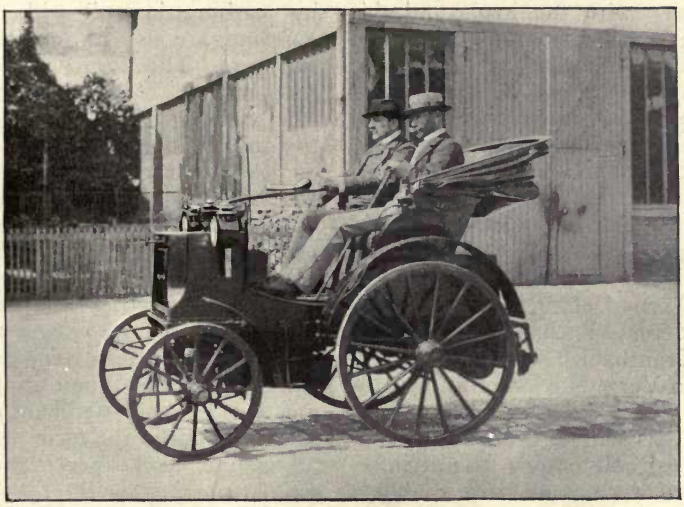
"A set of engines at Danbury, Conn., were built by the Otto Gas Engine Works with the provision that they could be operated indiscriminately by producer gas or by illuminating gas. The latter gas having about six times the heating value of the former, it will be easily understood that a compromise had to be resorted to in the construction, the result being that the engines do not give the best possible efficiency in either case. Engines built solely for producer gas would give better results.

"Since steam is used in the Danbury plant for various purposes, it was quite natural to employ a small steam engine for starting the gas engines. The large engines built now by us are provided with a self-starting device which renders the use of auxiliary power unnecessary and greatly enhances the convenience of operating the plant.

"The efficiency of a plant depends on the choice of the units of power, and perhaps a better result could be obtained in this case, if the units were differently selected. It should also be borne in mind that the producer used is large, and would be capable of furnishing gas for a greater amount of power, especially if the load factor was more favourable as it would be, for instance, in the operation of a mill or of a water-works, and I might well state here that gas power is being used extensively in Europe for the last named purposes.

"Up to this date it has been customary to use a steam boiler in connection with the producer. This is not a necessity, however, and we operate in our works a producer plant without boiler. The necessary amount of water vapour which passes with the air through the producer is generated at atmospheric pressure by means of the waste heat of the gas as it leaves the producer. There is thus no additional fuel used for producing steam, and, besides, the operation of the apparatus is rendered almost automatic.

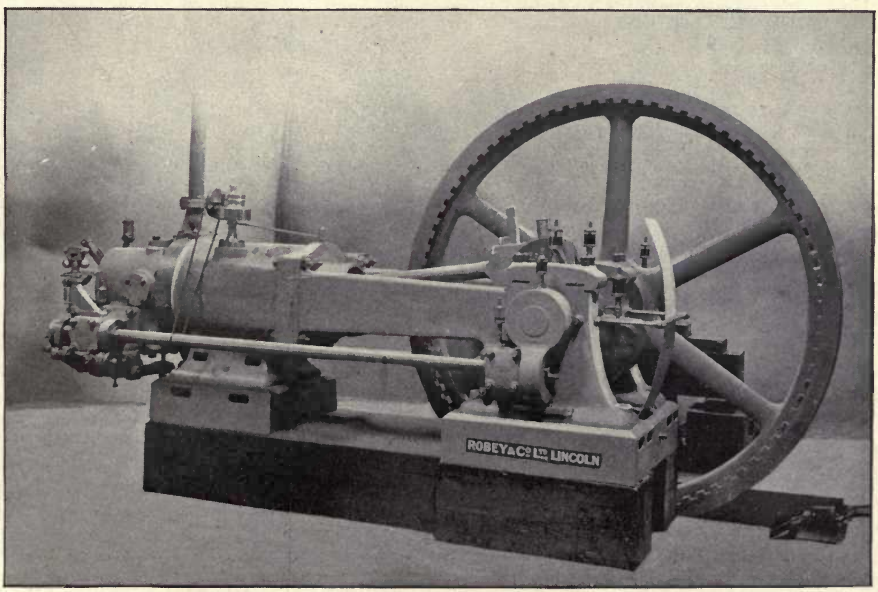
"Despite statements to the contrary, oil engines have been manufactured in the United States for several years, and considerable effort has been made for their introduction. We ourselves are fully prepared to begin their manufacture if a sufficient demand should arise. But in view of the fact that gasoline engines are so much preferable in most every respect, it is not surprising that the demand for oil engines should be so small. Gasoline engines have all the advantages of gas engines, and in some of those built in the United States to-day the provisions for safety are so absolute that the insurance companies have no objection to their use. Besides the objectionable smell which seems inseparable from the oil engine, there is the objection of its not being ready for starting at a moment's notice. Oil engines are naturally wasteful when running at partial and variable load. This is due to the fact that the proper de-



THE DAIMLER GASOLINE MOTOR CARRIAGE WHICH WON THE FIRST PRIZE IN THE PARIS ROAD CONTEST.

gree of temperature is not maintained at the different loads which occur in practice. When a continuous external flame is used for maintaining this temperature the fuel consumed in this flame decreases the efficiency at reduced loads.

"The oil engine described by Mr. Wildy was exhibited at the World's Fair. In this engine the ignition of the charge depends on the temperature of the chamber, which is left uncooled at the rear. The temperature of this chamber, and consequently the time of



GAS ENGINE, BUILT BY MESSRS. ROBEY & CO., LTD., LINCOLN, ENGLAND.

ignition vary with the load, and this circumstance produces an additional variation of the efficiency with the load.

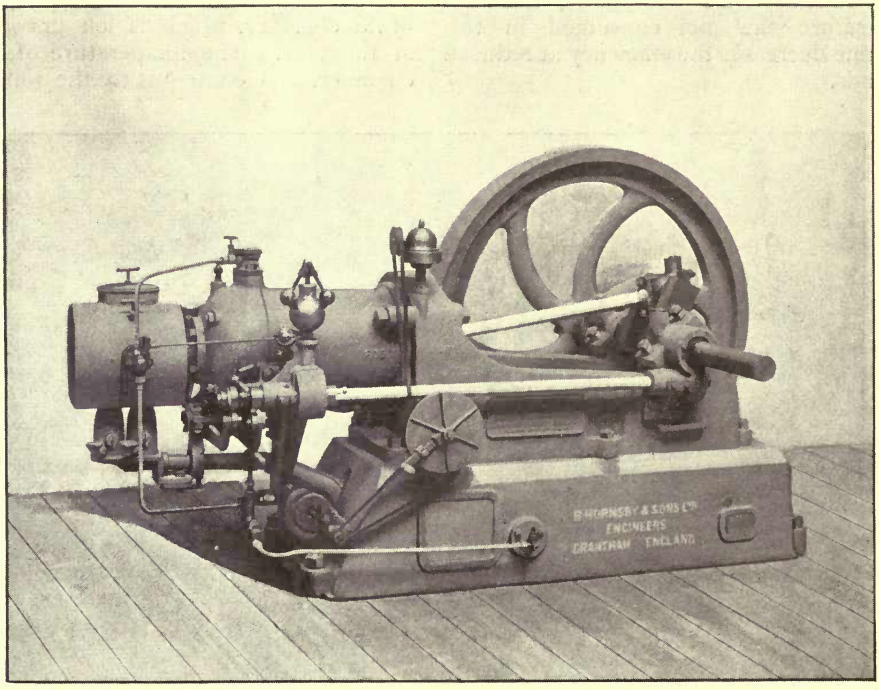
"Oil engines are naturally somewhat more complicated, more expensive, and less convenient than gasoline engines, and unless there be a marked difference in the prices of the two fuels, the latter would seem preferable in most cases."

Concerning oil engines generally, and particularly the already-mentioned Hornsby-Akroyd engine, built in England by Messrs. Richard Hornsby & Sons, of Grantham, and in America by the De La Vergne Refrigerating Machine Co., of New York, Mr. Geo. Richmond has sent us the following :—

"The term oil engine is not infrequently used, in a very loose manner, to describe a variety of engines in connection with which oil is used as a fuel. Steam engines in which steam is generated by liquid fuel are sometimes called oil engines. Gas engines, for which the gas is prepared on the spot by carburetting oil with naphtha or gasoline, are also improperly called oil engines. The term is properly restricted to an engine using a heavy oil from which gas cannot be made without the application of heat.

"As a thermal machine, the oil engine stands about on a par with the gas engine, and both are in this respect very much superior to the steam engine. The gas engine, however, is more costly to run when illuminating gas is used, for the reason that the gas companies charge a very much higher price per thermal unit in the form of gas than the coal merchant does for the same amount in the form of coal. The oil engine is cheaper than the gas engine in running for the reason that the cost per thermal unit in the form of oil is very much less than the cost of the same in illuminating gas.

"The oil engine really dates as far back as the gas engine, but while the latter rapidly reached a practical and



THE HORNSBY-AKROYD OIL ENGINE, BUILT BY MESSRS. R. HORNSBY & SONS, LTD., GRANTHAM, ENGLAND, AND THE DE LA VERGNE REFRIGERATING MACHINE CO., NEW YORK.

economic position, the former has not been put into an acceptable shape until quite recently. While an American can claim the honour of producing the first practical oil engine, its development was left to Europeans. Brayton, in 1872, patented and constructed at Exeter, in the United States, an engine using a heavy oil. A careful trial of a 5 horse-power, American Brayton petroleum engine was made at Glasgow by Mr. Dugald Clerk in 1878. The mean pressure was 30.2 pounds per square inch, diameter of cylinder 8 inches, length of stroke 12 inches. The engine made 201 revolutions per minute, and the consumption of petroleum was 2.16 pounds per indicated horse-power per hour. Much of the total power developed was absorbed in driving the air and petroleum pumps, or, in other words, there was a good deal of friction. During the trial the engine indicated 9.5 horse-power in the motor cylinder. Of this the pump absorbed 4.1 horse-power; therefore, the available horse-power was only 5.4. Only 6 per cent. of the total heat generated was utilized.

"The oil engine of the present day will convert into work 20 per cent. of the heat, and use somewhat less than one pound of oil per indicated horse-power. The chief practical objections to the gas and oil engines is the necessity of igniting the charge. The ingenious arrangement of Otto for transporting a flame into the body of the cylinder was in its day considered a triumph of mechanical skill. The dry heat to which the valve was subjected caused rapid deterioration and required frequent attention. This was followed by what is known as tube ignition, in which a tube is maintained at a red heat by a gas jet. The tube, like an incandescent lamp, has a life-time of a certain number of hours, and is certain to split, sometimes sooner, sometimes later. The third mode of ignition is the electric spark, for which a battery and spark coil must be kept in good running order. This, however, gives less trouble than the contact points themselves within the cylinder, which are liable to become covered with incrustation.

"The two systems of tube and electric ignition have each their advocates who claim great things for them. The fact that there are innumerable patents for improving them would seem to indicate that the difficulties sought to be overcome are not entirely imaginary, of

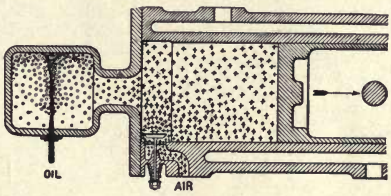


FIG. 1.

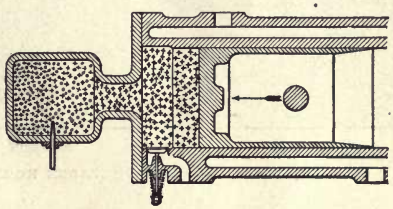


FIG. 2.

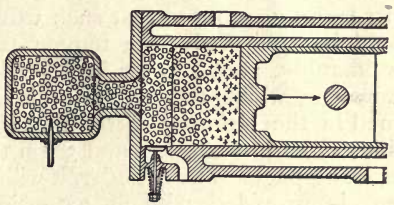


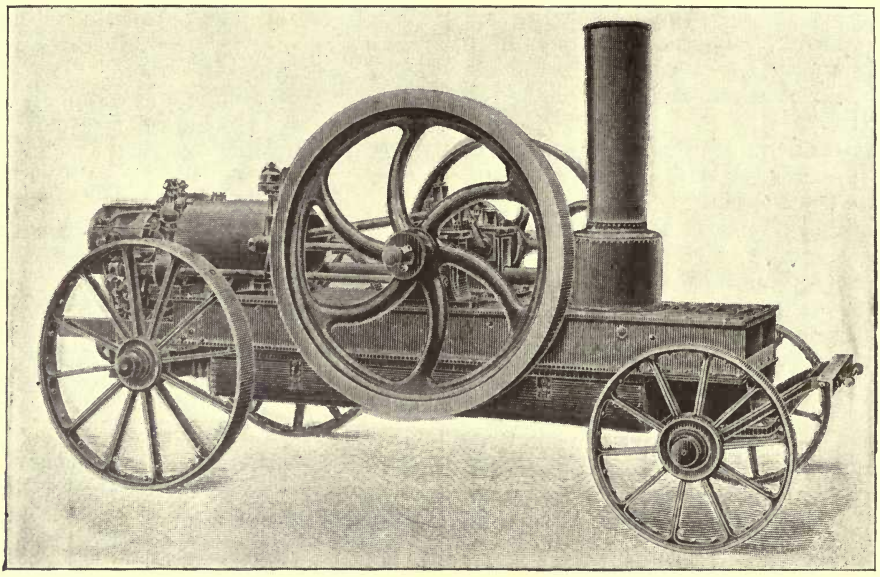
FIG. 3.

HORNSBY-AKROYD ENGINE DIAGRAMS.

+ Indicates pure air. ○ Indicates oil. □ Indicates products of combustion.

which fact no one is better aware than the user of a gas engine. It is worth while recalling the fact that Beau de Rochas, who described, even if he did not use, the four cycle, now known under the name of Otto, recommends that the compression should be carried to a point at which the explosion would be automatic.

"In the Hornsby-Akroyd engine we have the first example of a perfectly successful carrying out of this idea. The automatic explosion is not, in itself, difficult to realize. The real difficulty is in securing this explosion exactly at the moment required. The introduction of valve-motion for timing the explosion



A PORTABLE HORNSBY-AKROYD OIL ENGINE.

would naturally suggest itself, but it must be borne in mind that such valves would be subjected to a temperature considerably above red heat. The manner in which this explosion is obtained in the Hornsby-Akroyd engine is illustrated in Figs. 1, 2 and 3, on the preceding page. The cylinder, it will be seen, is provided with an extension, communicating with the cylinder by a relatively narrow neck. This extension is unjacketed, and forms a retort in which the oil is vapourized. Nothing but oil in the liquid form is injected into the retort, and only air is drawn into the cylinder. The operation, which is perfectly clear from the cuts, is as follows :—

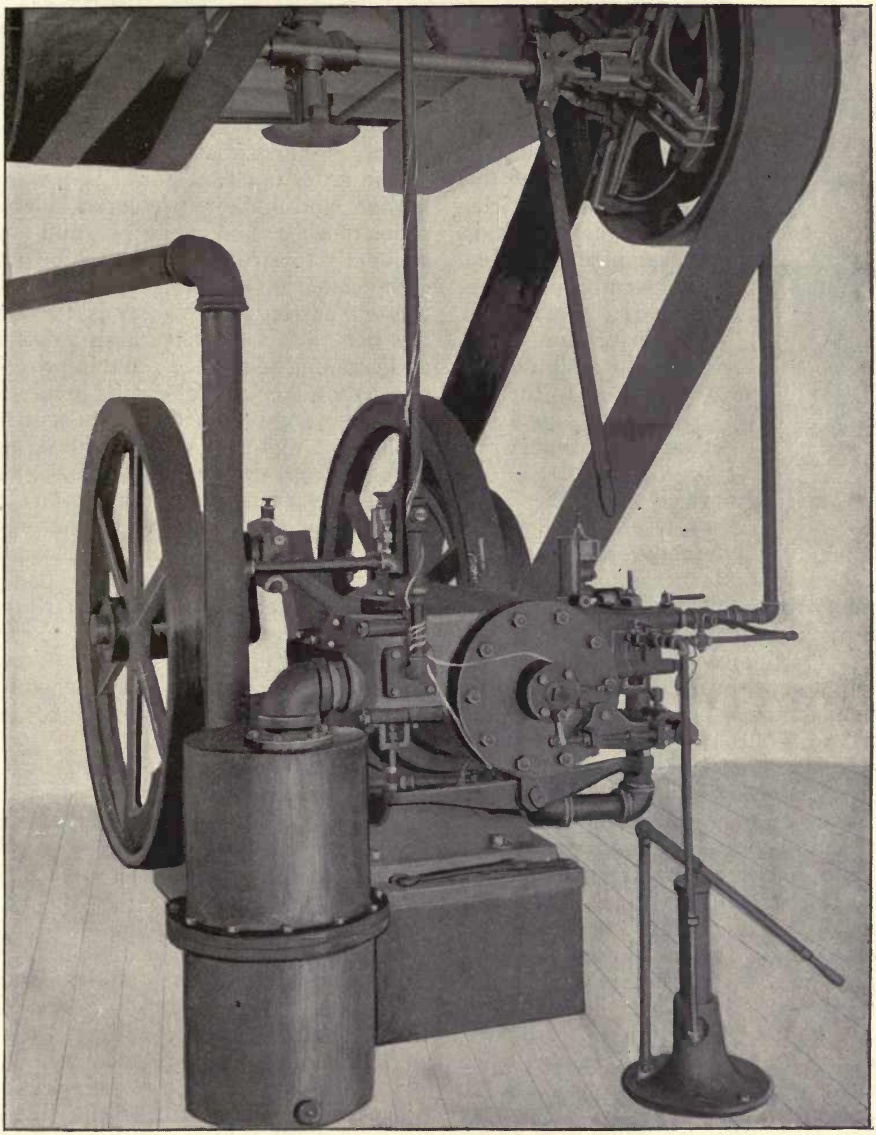
"On the outer stroke of the piston, air is drawn into the cylinder, and oil is injected into the red hot retort. At the end of the stroke we have, therefore, in the retort, oil vapour, which is not explosive, and, in the cylinder, pure air, which is not explosive ; nor is there sufficient leakage from the one to the other to make either of the charges explosive. On the return stroke of the piston, the air is forced from the cylinder through the communicating neck into the retort. For a time the mixture of oil, vapour and air is too rich for explosion, but, as the piston progresses, sufficient air is forced in to make the mixture explosive.

"Fig. 2 shows the mixing process, and Fig. 3, by the conventional marking, indicates that the explosion has taken place, and the cylinder and retort are filled with burned gases. This automatic explosion is found to take place exactly as the piston is making the return stroke.

"It will be noticed that the ignition takes place within the retort, the piston being protected by a layer of pure air. It is not claimed, of course, that these diagrams are exact representations of what actually takes place within the cylinder ; nevertheless, their substantial correctness seems to be indicated by the fact that the piston rings do not become clogged with tarry substance, as is usually the case with this class of engine. This surplus air should ensure complete combustion, and that it is accomplished is evident from careful analysis that have been made.

"At the De La Vergne Refrigerating Machine Company's Works, at New

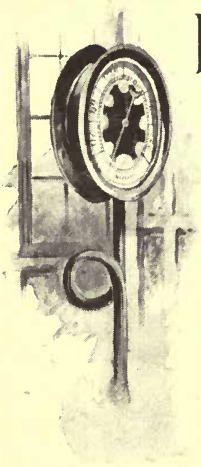
York, a Hornsby-Akroyd oil engine is running some wood working machinery for the pattern shop, and it is interesting to watch the promptness with which the governour adjusts the quantity of oil to the varying power which is taken off. The power will range from the full capacity of the engine to nothing, half-a-dozen times within ten minutes."



A 30 H.-P. ENGINE, BUILT BY THE NEW ERA IRON WORKS, DAYTON, OHIO U. S. A., RUNNING ON NATURAL GAS.

THE RECORDING GAUGE FOR STEAM PRESSURE.

By Charles A. Hague.



FOR many years the writer has been deeply interested from a professional standpoint in the subject forming the title of this article. And, the argument is at least plausible, that if the steam engine indicator, revealing a diagram of the forces within the cylinder, is so necessary to the designing and operating of steam machinery ; if the knowledge obtained from the indicator card has been so potent in bringing the steam engine successively and successfully through its many stages up to its present practical perfection, why should we not be equally well informed as to the conditions and operation of pressures within various kinds of vessels and pipes devoted to the useful employment of all sorts of fluids and gases ?

The fact really is, that it is absolutely necessary to be well informed as to the continuance, regularity and correctness for the purpose, of pressures where pressures are used. The steam engine is a more or less complicated machine, operated by a fluid, and often operating upon a fluid, the cause and effect of the energy used, so to speak, being subject to, and dependent upon, pressure. Could there be any folly greater, when searching and striving for economy in operation, than to remain voluntarily ignorant and in the dark, as to what has been, what is, and what probably will be?

Regularity, that key-stone to the arch, is just as easy of acquirement, and much more satisfactory to live with, than the uncertainty and irregularity too often prevailing in the management of organized effort involved in the uses of pressure and power. The tendency of the times in steam power is towards higher and higher pressures, higher ratios of expansion in engines, and consequently towards more expensive and complicated machinery. The study of the boiler designer to-day is to meet the demands for safety, high pressure and economical service ; and in proportion to the mechanical details involved, the boiler engineer's task is as arduous at least as that of the engine designer.

Aside from the question of fuel economy, the wear and strain upon the boiler by widely varying pressures within short spaces of time, even under the old regime of 70 pounds and under, was a great deal more serious than most people comprehended ; and to-day, with the load up to 150 and 200 pounds per square inch, the steadiness of the pull upon the metal is enhanced immeasurably in importance.

The modern, internally-fired boiler, with its heavy shell, its thickness calculated upon the relation between the elastic and ultimate tensile strength, and the load pressure to be used, is not proportionately as strong as its older and thinner-shelled brother. Materials decrease in strength value, as the thickness increases ; they do not so readily resile, and the liability to permanent distortion of section is greater. It is a very reasonable theory that in cylindrical vessels, when the pressure per square inch approaches the tensile strength limit, adding to the thickness will not increase the strength of the vessel.

Reference to figures will aid the mind in grasping and appreciating the sort of experience a boiler plate goes through,

TJ785
S65
464520
UNIVERSITY OF CALIFORNIA LIBRARY